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THE SCIENCE AND ART

OF

SURGERY.

"*They be the best* Chirurgeons *which being learned incline to the traditions of experience, or being empirics incline to the methods of learning.*"

BACON *on Learning.*

THE SCIENCE AND ART OF SURGERY.

A Treatise on Surgical Injuries, Diseases, and Operations.

BY

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EIGHTH EDITION.

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PREFACE

TO THE EIGHTH EDITION.

THE Author had long felt that a complete revision of this work had become necessary, in order to bring it on a level with Modern Surgery in its Science as well as in its Art.

Much that was antiquated had to be eliminated from its pages—more that was new in Pathology as well as in Practice required notice; for in no corresponding period in the history of Surgery has so great an advance been made in all its departments as in that which has passed since the last edition of this work was published.

The labour demanded by such complete revision of a work extending over so wide a field as this does, was greater than he could now undertake single-handed. He therefore sought, and was fortunate in obtaining, the co-operation of his old pupil—his colleague and friend, Marcus Beck. To him has been mainly entrusted all that relates to Pathology. To this task Mr. Beck has brought not only an extended practical knowledge of Surgical Pathology, enabling him to speak with authority from, and to test the doctrines of others by, his own observations, but a thorough acquaintance with the work of others in this field of science. In those parts of the book also which relate to Clinical and Operative Surgery he has done much in assisting the Author to bring up these subjects to the level of the more advanced methods of modern practice.

The Author's friend and former pupil, William A. Meredith, most

kindly undertook the revision of the Chapter on the Surgical Treatment of some Uterine and Ovarian Diseases—a subject for which his special acquaintance with these affections peculiarly fitted him.

To Stanley Boyd the Author is indebted for much valuable assistance in carrying the work through the Press; and to Victor Horsley for some of the new drawings by which it is illustrated.

About one hundred and fifty new Figures have been added, drawn from nature by W. H. Wesley, and engraved by G. Pearson, some of the old ones are cancelled, and many re-drawn. Whenever a woodcut has been taken from another work, the name of the author of the work whence it has been taken has been appended to it. When no such acknowledgment is made the Figure is original, belongs exclusively to this work, and, except in the case of diagrams, has been drawn from nature. The Author may be excused from laying stress on these points, as many of his illustrations have been copied into other works on Surgery without acknowledgment of the source whence they have been taken.

Arrangements have been made for the appearance, simultaneously with the English Edition, of a new American reprint of the work, and of new Translations of it into Italian by Dr. Antonio Longhi of Milan, and into Spanish by Dr. Ulecia-y-Cardona of Madrid.

The Author feels that a responsibility, weighty in proportion to the very extent of this wide diffusion of his Instruction, is incurred by him who takes upon himself the task of teaching others that Science which underlies the Art, and that Art, the exercise of which constitutes the application to Practice of a great branch of Medical knowledge, which more directly than any other department of Medicine involves the physical well-being, and more immediately affects the life of those on whom it is exercised.

It is not sufficient that the Teaching of a Scientific Art, such as Surgery, should be sound in those General Laws that constitute its Principles. It must also be accurate in those minute details that are

necessary to its successful Practice, and, above all, just in its estimate of the labours of others.

A Teacher of Surgery, who seeks to give a true and impartial view of the subject of his tuition, is placed in much the same position as a Judge who is summing up a great cause.

He must endeavour to divest himself of the trammels of the Schools —to free himself alike from the partisanship of individual bias and the prejudice of professional antagonism.

He must lay down clearly the broad General Principles on which the Case rests; detail its facts in an orderly and succinct manner, draw those deductions which legitimately flow therefrom, and guide his Pupils to arrive at just conclusions by the light of his own more matured and extended experience.

Throughout the Work it has been the object of its Author to place before the Student and Practitioner the Science and the Art of Surgery—not as consisting, merely, in the observation of such Injuries, Diseases, and Malformations, as are met with in Surgical Practice or in the dexterous application of manual or operative means for their relief; but as demanding an exercise of general medical knowledge, and a thorough acquaintance with all those conditions, whether intrinsic to the patient, or surrounding him, that favour or prevent his restoration to health. The remarks in the earlier part of the First Chapter, will, it is trusted, sufficiently indicate to the Student what is required of him in order that he may become a successful Practitioner of Surgery.

In every instance an endeavour has been made to give as full and clear a description of Symptoms, Pathology, Diagnosis, and Treatment, as the importance of each demands, and the present state of Surgical knowledge permits.

The various new Operations practised in modern Surgery have been carefully described, the difficulties and dangers attending their performance pointed out, and the cases requiring them detailed.

The paramount importance of Surgical Hygiene, both general and

local, has led to special attention being paid to it in the Chapters on Operations, Wounds, and Septic Diseases.

With respect to Diagnosis it may be remarked that, as accuracy in this branch is an all-important requisite for success in Treatment, the signs and symptoms by which the injury or disease under consideration may be recognised, have not only been described in each case, but care has been taken, even at the risk of occasional repetition, to point out the several conditions with which it may be confounded, and the means of distinguishing it from each of them.

The Chapter on the Operations practised on the Eye has been omitted. The Author felt that as it was impossible, in a Work on General Surgery, to devote sufficient space to the consideration of so wide and important a Special Department as that of Ophthalmology, it would be better to omit so very limited a part of it as that which concerned only its Operations, when the Diseases for which they were practised could not be described. This omission has been rendered the more necessary as, notwithstanding every care in keeping out superfluous or extraneous matters, the size of the volumes of the present Edition considerably exceeds that of the last.

More than thirty years have passed since this Work was first published. During this lengthened period it has met with no inconsiderable amount of favour in this and in other countries. The Author can but hope that the present Edition in its extended and amended form may not be found undeserving of the continued confidence of the Surgical Profession as a text-book for the Student, and a guide for the Practitioner in Surgery.

JOHN ERIC ERICHSEN.

LONDON, 1884.

CONTENTS OF THE FIRST VOLUME.

DIVISION FIRST.

FIRST PRINCIPLES.

CHAPTER I.—GENERAL CONSIDERATIONS ON OPERATIONS.

CHAPTER II.—AMPUTATIONS AND DISARTICULATIONS.

PAGE

CHAPTER III.—SPECIAL AMPUTATIONS.

CHAPTER IV.—LOCAL DISTURBANCES OF CIRCULATION, AND INFLAMMATION.

CHAPTER V.—SUPPURATION AND ABSCESS.

CHAPTER VI.—ULCERATION.

CHAPTER VII.—THE PROCESS OF REPAIR.

DIVISION SECOND.

SURGICAL INJURIES.

INJURIES AFFECTING THE TISSUES GENERALLY.

CHAPTER VIII.—CONSTITUTIONAL EFFECTS OF INJURY.

CHAPTER IX.—INJURIES OF SOFT PARTS.

CHAPTER X.—GUN-SHOT WOUNDS.

CHAPTER XI.—POISONED WOUNDS.

CHAPTER XII.—EFFECTS OF HEAT AND COLD.

CHAPTER XIII.—INJURIES OF BLOOD-VESSELS.

PAGE

Chapter XVIII.—Special Injuries of Nerves, Muscles, and Tendons.

Chapter XIX.—Injuries of Bones and Joints.

Chapter XX.—Fractures.

Chapter XXI.—Special Fractures.

CHAPTER XXII.—DISLOCATIONS.

CHAPTER XXIII.—SPECIAL DISLOCATIONS.

PAGE

Chapter XXVII.—Injuries of the Throat: and Asphyxia.

Chapter XXVIII.—Injuries of the Chest.

Chapter XXIX.—Injuries of the Abdomen and Pelvis.

DIVISION THIRD.

SURGICAL DISEASES.

CHAPTER XXX.—MORTIFICATION OR GANGRENE.

CHAPTER XXXI.—DISEASES ARISING FROM SEPTIC AND INFECTIVE PROCESSES IN WOUNDS.

CHAPTER XXXII.—ERYSIPELAS.

PAGE

Chapter XXXIII.—Septicæmia and Pyæmia.

Chapter XXXIV.—Tumours.

CHAPTER XXXV.—SCROFULA AND TUBERCLE.

CHAPTER XXXVI.—VENEREAL DISEASES.

LIST OF ILLUSTRATIONS TO VOL. 1.

DIVISION FIRST.

FIRST PRINCIPLES.

CHAPTER I.

GENERAL CONSIDERATIONS ON OPERATIONS.

By a Surgical Operation is meant a Manual or Mechanical Process undertaken by the Surgeon for the remedy of Deformity, congenital or acquired, or for the cure or relief of a patient suffering from those effects of Injury or Disease, that are incurable by constitutional or ordinary local treatment, or in which such treatment would be too slow in effecting the desired result.

A *Surgical Operation* may be necessary for the following objects :

1. *Remedying or Removing Congenital Defects and Malformations :* as Hare-lip, Club-foot, or Supernumerary Fingers or Toes.

2. *Remedying Acquired Defects and Deformities :* as in the Closure of Fistulæ, the Restoration of Lost Parts, and the Correction of Distortions of the Limbs.

3. The *Removal of Foreign Substances* from the Body : as in the Extraction of a Bullet or a Calculus.

4. The *Repair of the Effects of Injuries :* as in the treatment of certain Fractures and Dislocations.

5. The *Removal of Parts* that have been so disorganised by the effects of *Injury* that their vitality is lost, or that their continued connection with the rest of the body would be a source of danger : as in Amputation for Frost-bite or Mangled Limbs.

6. The *Removal of Diseased Structures* that interfere with the utility of an organ or part : as in the Extraction of a Cataract.

7. The *Removal of Diseased Structures* that seriously inconvenience the patient or that remotely threaten life : as in the Extirpation of Tumours, Simple or Malignant.

8. *Rescuing a Patient from Immediate and Inevitable Death :* as in Tying a Bleeding Artery, Opening the Windpipe in Laryngeal Obstructions, Relieving an Over-distended Bladder, or Dividing the Stricture in Strangulated Hernia.

Operative Surgery is but the application of manipulative methods to the relief and cure of injury and disease. Like every other art, be it manipula-

tive, plastic, or imitative, it can be carried only to a certain definite point of excellence. An art may be modified—it may be varied—but it cannot be perfected beyond certain attainable limits. And so it is, and indeed must be, with that of Surgery. There cannot always be fresh fields for conquest by the knife. There must be portions of the human frame that will ever remain sacred from its intrusion—at least, in the Surgeon's hand.

That we have nearly, if not quite, reached these final limits there can be little question. When we reflect that every large artery in the human body up to the aorta itself has been repeatedly ligatured—that each of the six large articulations and many of the smaller bones have been resected—that the amputation of each limb up to the shoulder- or hip-joint is a matter of ordinary surgical occurrence—that large tumours having the most intricate anatomical connections have been removed from every surgical region in the body, from the base of the brain to the lowest organ in the pelvic cavity—that the larynx, the spleen, the kidney, the pregnant uterus, and even portions of the stomach have been successfully removed—when we reflect on triumphs of the Surgeon's art that are expressed by operations such as these, we can scarcely believe otherwise than that little remains for the daring of the boldest to devise, or the skill of the most dexterous to accomplish, in the extension of that art in the direction of its operative department, and that the Surgeon must in future be content to repeat, though possibly in a modified and improved manner, those operations that have been inaugurated by the genius and perfected by the skill of his predecessors.

It is true that some of the operations recently performed for the removal of important organs have been far from successful, and it has yet to be determined whether they are more than bold experiments on the power and endurance of the human frame; whether they are surgical triumphs or operative audacities.

To my mind, it appears as if we had already reached something like finality in the mere manipulative art of Surgery; though I hesitate much to use the word "finality," for I know well how apt a man is to suppose that art, to the prosecution of which he has devoted his life, to have attained its final limit of perfection. Yet, looking at the question as dispassionately as possible, we cannot but come to the conclusion—that we can scarcely hope to pass far beyond the line at which we have arrived in the direction of extreme precision and almost absolute certainty in the mechanical performance of the operations of surgery, and that in this direction the progress of modern Surgery is nearly barred. At the same time, we may reasonably expect that the details of the methods of practising operations may from time to time be materially modified and improved by the skill of individual operators, by the ingenuity of surgical mechanicians, or possibly by the introduction of new agents as aids to our art.

But if modern operative Surgery has attained to so high a pitch of perfection in all that relates to boldness of conception and to precision of execution that we can scarcely hope to see any further progress in these directions; and, indeed, if the most advanced modern Surgery is seeking to lay aside the scalpel and the bistoury for milder methods of treatment—if, in fact, the practical department of Surgery has, so far as our present means and our present knowledge are concerned, reached, or nearly so, its final development—the case is widely different with the other great branch of Surgery—the *scientific*.

For here, truly, so far from having approached the final limits of our subject,

we are but as yet on the threshold. And whether we regard the science of Surgery in its relation to the essential nature, the character, the recognition, and the pathology of surgical diseases and injuries, or whether we consider it in reference to all those circumstances which, independently of the mechanical skill of the operator, influence for good or for ill the results of his procedures, we have a field before us the extent of which it is difficult yet to estimate.

And here I do not speak of the mere local results; so far as they are concerned, there has long been but little to be desired. The results of most plastic, conservative, and ophthalmic operations have been as satisfactory as the most sanguine could hope for or the most critical expect. So also with respect to that multitude of minor operations that are practised for the relief of various distressing maladies, and which are followed by the happiest consequences. But when we come to consider the issues of those greater and graver operations, by which the life of a patient is directly imperilled, we are constrained to admit that success in results long lagged far behind and bore no relation to the perfection in the execution of the operation, and that in this respect the highly polished Art of Surgery formerly far outshone its Science.

Since this was written, now ten years ago, much of its force has been lost. For the treatment of wounds, whether accidental or inflicted by the Surgeon's knife, has been greatly improved by the application of scientific methods to their management, and operations have been correspondingly rendered more successful in their results. We have, in fact, arrived at one of those epochs in the history of Surgery which stand out prominently as starting-points from which a new departure is taken in its Art—either in relation to its practice generally or in the development of some special department. Amongst the most important of these epochs, so far as the improvement of the general practice of Surgery is concerned, are those marked by the revival of the use of the Ligature in the sixteenth century, and by the introduction of the Hunterian operation for Aneurism in the eighteenth. The nineteenth century will ever stand out brightly in the annals of Surgery as that in which the inestimable boon of Anæsthetics was conferred upon mankind, by which not only has pain in Surgery been abolished, but the extent of its operative department immensely enlarged, for they enable the Surgeon to perform, and the patient to undergo procedures, the agony of which would otherwise have been beyond the power of human endurance. A scarcely less noticeable feature in the Surgery of this epoch is the application of the rules of a scientific hygiene to the treatment of the injured, and the methodical employment of Antiseptics in the management of wounds. Founded, as the "Antiseptic Method" is, on the experimental researches of Pasteur, it is undoubtedly to Lister that Surgery owes the application to Surgical Practice of the doctrines established by that great Biologist. However much the details of the *Antiseptic Method* may be varied in the course of time and by the introduction of new chemical agents, the grand principle which sub-lies it, and on which the whole superstructure of its details is built, will run on intact and unchangeable. This principle is as follows:—That the decomposition of fluids in wounds, their putrefactive changes, in short, are directly dependent on their impregnation with organic matter, floating in the air, and thence deposited or in other ways conveyed to them, fermentative or putrefactive changes being thus at once set up in the fluids of the wound; that such local actions are capable of producing general septic infection of the fluids of the body; and further, that these organic

products may be excluded from the wound, either by their destruction in the air by chemical agents, such as carbolic acid, or their separation from it by filtration, as by layers of muslin or of cotton wool. It is this doctrine that has revolutionized the practice of modern Surgery. The details by which it is carried out are necessarily changeable. The Principle itself is immutable, for it is based on, and is the outcome of, direct experiment and observation.

Success in the results is, after all, the thing to aim at, and no amount of manual dexterity can compensate for its want. But it must not be supposed, that manual dexterity is to be undervalued—far from it. Manual dexterity is necessarily of the first advantage in the performance of any operation, and the Surgeon should diligently endeavour to acquire the Art of using his instruments with neatness, rapidity, and certainty. In many cases of minor moment, no other requisite is needed by the Surgeon than this. But it would, indeed, be a fatal error to suppose that, in the majority of cases requiring surgical interference, this is the only or indeed the chief requirement on the part of the operator. Manual dexterity must not be mistaken for surgical skill ; and, desirable as it doubtless may be to be able to remove a limb, or to cut out a stone, with rapidity,—important, in a word, as it is to become a dexterous operator—it is of far greater importance to become a successful Surgeon. The object of every operation is the removal of some condition that either threatens life, or interferes with the comfort and utility of existence ; and the more safely as well as certainly a Surgeon can accomplish this object, the better will he do his duty to his patients, and the more successful will he be in his practice. Success then, in the result of an operation, whether that result be the preservation of life or the removal of a source of discomfort, is the thing to aim at. To this, dexterity and rapidity in operating are in a high degree conducive ; but there are various other considerations equally or still more necessary, the solution of which can be afforded only by an intimate general acquaintance with the Science of Surgery and of Medicine. The Diagnosis of the nature of the local disease, and of the extent of its connections, has to be made ; lurking visceral affections must be detected and, if possible, removed. The Constitution of the patient must be prepared ; he must, as far as possible, be placed in those hygienic conditions which are most favourable to recovery ; the best time for the performance of the operation must be seized ; and, after its completion, the general health must be attended to in such a way as shall best carry the patient through the difficulties he has to encounter ; and any sequelæ or complications that arise must be subjected to appropriate treatment. These, as well as the simple performance of the operation, are the duties of the Surgeon ; and on the manner in which they are performed, as much as, or even perhaps more than, on the mere manual dexterity displayed in the operation itself, will the fate of the patient depend. It is well known that the result of operations differs much in the practice of different Surgeons of acknowledged dexterity ; and this variation in the proportionate number of recoveries cannot be accounted for by any difference in the degree of manual skill displayed in the operation itself, but must be sought rather in the greater attention that is paid by some Surgeons to the constitutional treatment of their patients before and after operation, and to their more perfect acquaintance with those general laws that influence the success of all the operations of Surgery. Indeed, success in Operative Surgery mainly depends on two

conditions: 1. The selection of proper cases; that is to say, of cases in which alone an operation will probably be followed by a successful result; and 2. the avoidance or the combating of those deleterious influences, hygienic and others, to which a patient may be exposed after an operation, and which may directly mar its success.

Two requisites are thus essentially needed to constitute a successful operator. The first is, the possession of that mechanical skill which is required for the safe, efficient, and speedy performance of an operation; the second, of at least equal importance, is the scientific knowledge requisite to determine the cases in which operation has become necessary, in which it may be practised with a reasonable prospect of benefit and success, and to decide on the means to be adopted to place the patient in the most favourable circumstances for recovery.

The practice of operating in notoriously hopeless cases, with the view of giving the patient what is called "a last chance," is much to be deprecated, and should never be followed. It is by operating in such circumstances, especially in cancerous diseases, that much discredit has resulted to Surgery; for in a great number of instances the patient's death is hastened by the procedure, which, instead of giving him a last chance, causes him only to be despatched sooner than he would otherwise have been. It may truly be said that a great surgical operation, in its conception, its performance, and its completion, tests the Surgeon's medical knowledge as much and in as varied a manner as it taxes his manual skill; and that, taken as a whole, it is the highest development of the medical art.

CONDITIONS INFLUENCING THE SUCCESS OF OPERATIONS.

The circumstances that mainly influence the result of an operation, so far as the recovery of the patient is concerned, may be arranged under three heads:— 1. Those that are connected with the *State of the Patient's General Health* before and at the time of its performance; 2. The *Hygienic Conditions* by which he is surrounded after it is done; and 3. The *Special Dangers* connected with the operation itself.

1. All other circumstances being alike, the condition of a patient that principally determines the result of an operation is the **State of the General Health.** Indeed, success is influenced far more by the state of the patient's constitution than by the severity of an operation itself, or even by the mechanical dexterity with which the Surgeon performs it. Very often we see a patient carried off by fatal disease supervening on some extremely trifling operation, (such as the removal of a small tumour,) which in itself ought in no way to endanger life, were it not that the patient's constitution was at the time of its performance in so unhealthy a state that the slightest exciting cause has been sufficient to call the fatal disease into activity. So, also, it is no uncommon circumstance to see one patient sink after the most dexterously performed operation for hernia, or stone, the ligature of an artery, &c., owing to some constitutional condition that predisposes to diffuse inflammations; whilst another may possibly make the most remarkable and rapid recovery after he has been mutilated with but little skill. Independently of actual organic disease of the viscera, of which I shall hereafter speak, there are certain conditions of the body with respect to the condition of the nervous system, the circulation, and the general physical state, that

exercise an injurious influence. Thus, persons of an irritable and anxious mind do not bear operations so well as those of a more tranquil mental constitution. Those also of a feeble and irritable habit of body, especially nervous and hysterical women, with but little strength of circulation, cannot bear up against severe surgical procedures, and often sink after comparatively slight ones; being apt to become depressed and to sink without rallying. Persons who are overloaded with fat are not good subjects for surgical operations. In them the circulation is usually feeble; the wound heals slowly and is apt to become sloughy; and general or local infective processes readily occur. Short of actual structural disease of important organs, as the lungs, heart, or kidneys, I know no condition more unfavourable to success after operations than premature or excessive obesity.

Patients with a high temperature should never be operated on except for the relief of that very condition which occasions the elevation of temperature, such as the accumulation of pus, or rapidly spreading gangrenous inflammation, or in one of those four great surgical emergencies that demand under all and every circumstance immediate operation; viz.: 1, dangerous hæmorrhage; 2, impending asphyxia; 3, strangulated hernia and intestinal obstruction; and 4, over-distended bladder. The urgency of these conditions, which may be termed the four classes of primary surgical urgency, overrides all other considerations.

An individual of a sound constitution, that has never been impaired by excesses of any kind, whose habits have been temperate and sober, whose diet has been sufficient and of good quality, whose mind has never been overstrained by the anxieties of business or the labours of a professional life, and whose existence has been spent in rural occupations and in the pure air of the country, is necessarily placed in a far more favourable position to bear the effects of any mutilation, whether it be the result of injury or be inflicted by the Surgeon's knife, than the man whose physical powers are worn out by active and unceasing business-avocations or professional work, whose nervous system is exhausted by his anxious labours; and infinitely more so than the poor inhabitant of a large and densely peopled town, who has from earliest childhood inhaled an impure and fœtid atmosphere, whose scanty diet has consisted of the refuse of the shops, or the semi-decomposed offal of the stalls, and whose nervous system has been irritated and at the same time exhausted in the daily struggle for a precarious livelihood, or over-stimulated by habitual excesses in strong drinks, by which he has hoped to purchase temporary forgetfulness of the cares of a sordid life. Though individuals with such different antecedents be placed under exactly the same hygienic circumstances *after* the performance of an operation, yet the results will probably be very dissimilar, influenced as they must be by their past rather than by their present condition. In the one case, the inflammation resulting from the incision, and requisite for the cure of the wound, will not overstep the normal degree necessary for the healing process. In the other it may assume a spreading form and terminate in some of those secondary affections which will presently be adverted to as occasioning death under unfavourable hygienic conditions.

Besides the general state of the patient's health, the *Condition of Important Organs* must be taken into consideration before an operation is decided on. The state of the patient's *Heart* should be carefully looked to. Valvular disease of this organ, if early or slight, need not be an obstacle to most

operations, even to those of expediency; but fatty degeneration of the heart, as indicated by its feeble action, by irregularity and want of power in the circulation, by breathlessness, and by a distinctly marked arcus senilis, should make the Surgeon careful in undertaking any operation attended with much loss of blood or shock to the nervous system. Such a condition of heart is liable to occasion great depression of strength, syncope, and death—often sudden—some days after the operation. In cases of chronic disease that it would otherwise be proper to submit to operation, this condition of the heart becomes a serious obstacle, but it need not be a bar to operation in acute cases that would be speedily fatal if left to themselves, and certainly not in one of the four conditions of primary surgical urgency.

Disease of the *Lungs*, of a tuberculous character, when active or advanced, is incompatible with the success of an operation; but under certain circumstances, as will be explained when speaking of diseases of the joints and fistula in ano, an operation is justifiable and proper, even though the patient be consumptive.

If the *Liver* be affected by cirrhosis, and more especially if any symptoms of ascites have supervened, no operation but for the relief of disease that instantly threatens life should be undertaken. Amyloid degeneration does not counter-indicate an operation if, by that operation, the cause of the condition can be removed, as in some cases of chronic joint disease.

Perhaps the most serious constitutional affection, and that which more than any others militates against the success of an operation, is disease of the *Kidneys*, with albuminuria; in this condition the local inflammation that is set up is apt to assume a diffuse and sloughing form, and this is especially the case in all operations about the pelvic and genito-urinary organs.

Saccharine diabetes is another constitutional condition which absolutely forbids all operations except those required for the immediate preservation of life. The tendency to the occurrence of carbuncle and spontaneous gangrene in diabetes is a well-known feature of the disease, and this tendency shows itself after an operation in sloughing of the surfaces of the wound, with widely-spreading diffuse inflammation followed by septicæmia and death. Albuminuria and diabetes form, in fact, such serious complications, that no operation, even the most trivial, should be undertaken, except in cases of emergency, without previously examining the urine both for albumen and sugar.

The contamination of the patient's system by Malignant Disease must always prevent our operating; as, if this has taken place, the disease cannot be completely removed. And, lastly, no operation, save of the most urgent necessity in cases that fall within the category of one of the four classes of primary surgical urgency, and thus intended to rescue the patient from impending death, should ever be performed whilst he is labouring under Pyæmia, Septicæmia, Erysipelas, Phlebitis, or any Diffuse Inflammation; and even during the epidemic prevalence of these affections, operations that are not of immediate necessity should be postponed until a more favourable season. Operations in very old people, if severe and attended by much shock to the system, are commonly fatal; amputations in individuals above the age of seventy, are very rarely successful.

2. **The Hygienic Conditions** to which a patient is exposed both before and after an operation, will most materially influence its results. These conditions are of two kinds:—1. As regards the diet of the patient, and 2. As concerns

his exposure to a vitiated atmosphere contaminated by the emanations from the sick and wounded, such as is commonly met with in the wards of an over-crowded or ill-constructed hospital.*

The proper regulation of the patient's *Diet* before and after an operation is of great consequence. On this point it is impossible to lay down any very definite rule, as much depends not only on the patient's previous habits of life, but on the nature of the operation itself; and, as this subject will be discussed at the end of the Chapter, it need not detain us here. It is not, however, often that in civil practice the insufficient quantity or the bad quality of the patient's food, with which he is supplied *after* the performance, influences materially the result of an operation. But in military and naval practice in time of war the case is far different. The soldier or the sailor on active service is often exposed to serious injuries that necessitate the more important operations at a time when his constitutional powers have already been broken down by scurvy, dysentery, or some other similar affection, resulting as much from the deficient quantity as from the unwholesome character of the food with which alone he can be supplied. After the operation his only available nutriment may be of the coarsest character, possibly salted, and imperfectly cooked. In such circumstances operation-wounds do not heal, or they assume a peculiar gangrenous character; and the patient dies from septicæmia or pyæmia, or from profuse diarrhœa with ulceration of the intestines. The mortality of operations becomes enormously increased; and thousands of deaths which have occurred in wars between the most civilised nations and the best appointed armies have been due to these causes.

The *Hygienic Conditions* to which the patient is subjected after an operation will necessarily vary greatly according to the locality in, and the circumstances under, which it is performed—whether it is done in a private house, where the patient may be isolated, freed from the chance of all contamination, and surrounded by every sanitary precaution; or in a hospital, where he must necessarily be exposed to emanations, possibly of a septic and infectious character, from other patients, where the building may be impregnated by the exhalations from generations of sick and injured, and where sanitary measures may be neutralised by the conditions generated by a vast assemblage of sick under one roof. Then, again, the circumstances in which a patient is placed after an operation for an accident of civil life are necessarily very different from those that surround one who is exposed to the peculiar perils that are necessarily connected with military hospitals and ambulances in time of active war, and which will be more fully described in the chapter on Gunshot wounds.

In private practice, ill results may follow operations from three different causes, viz.: self-infection of the patient, in consequence of the retention of decomposing and putrescent secretions in the wound; conveyance of infection by the Surgeon; and general faulty sanitary arrangements of the house. In hospital practice these different sources of danger must necessarily exist to the same if not to a greater extent than in private. In hospital, however, just as in private practice, these particular dangers are all preventable, and disease of a septic character ought not to be allowed to generate itself through their medium. The frequency of such an occurrence is in the direct ratio of the want of hygienic attention bestowed upon the patient. But in addition to these causes

* I would refer the reader who wishes to study this very important subject more deeply to my "*Lectures on Hospitalism and the Causes of Death after Operations.*" Longmans, 1874.

of disease, there exists in hospitals one special source of danger which leads to the excessive mortality that up to a recent period has prevailed in most of these institutions, and which unfortunately is still allowed to be prevalent in some. This danger results from the accumulation of large numbers of sick and injured people in one building.

The air of large towns or cities in which the great majority of hospitals must necessarily be situated is, to begin with, more or less loaded with impurities. The normal ·4 parts per 1,000 of carbonic acid gas is always exceeded, the amount sometimes reaching as high as ·5 or ·55. The amount of solid impurity is also very considerable. It has long been known that the atmosphere is loaded with minute particles of organic matter in a state of suspension. More than twenty years ago Pouchet demonstrated the presence of starch granules in the dust deposited in a room. In 1861 Pasteur proved that the spores of fungi were always to be found in the air of Paris. Tyndall has also shown how large a proportion of the dust of the air is composed of organic matter. Nothing is more simple than to demonstrate this impurity of the air by the method recommended by Koch of Berlin in which the development of the various fungi can be watched on a boiled potatoe, the cut surface of which has been for a short time exposed to the air, and then covered with a bell jar. By a similar method of observation the presence of the spores of fungi, and occasionally of bacteria, may be shown in the dust deposited on the tops of doors, picture-frames, &c. Microscopic examination shows in the air of all inhabited rooms, scaly epithelium, bits of human hair, and fibres of cotton, linen, and wool from the clothing. All these impurities are easily to be recognised by simple microscopic examination of the dust filtered from the air. The experiments of Pasteur, Tyndall, Lister, and a host of other observers have conclusively proved that the air contains also minute solid particles, often incapable of ocular demonstration, which act as ferments upon dead organic matter giving rise to such processes as the ordinary putrefaction of albuminoid substances, the lactic acid fermentation of milk and the like. Pasteur and his disciples maintain that in all cases these particles are living organisms or their spores. Pouchet, Bastian, and others, however, while not denying that such minute particles do exist in the air, and that they do act as ferments when they come in contact with fermentable matter, believe that they are not organised bodies, but are particles of organic matter undergoing certain "physico-chemical changes." They also assert that under favourable circumstances putrefaction and analogous processes can occur spontaneously without the intervention of any such bodies. Be that as it may, the weight of evidence at the present time is certainly in favour of the view that under ordinary circumstances, that is to say, under such conditions as we meet with in 99 out of 100 surgical cases, no putrefactive or fermentative change will take place in the secretions or exudations in the living body if the dust of the air be excluded; or, if that is impossible, if the particles of which it is made up be exposed to the action of some one of those chemical agents which we class as antiseptics.

The air of a surgical ward or sick room is vitiated by the patient, firstly by the normal products of respiration and excretion from the lungs and skin; and secondly, in many cases by the emanations from wounds or sores. The first is unavoidable, the second is to a great extent under the control of the Surgeon.

An average adult man gives off per hour about ·6 cubic feet of carbonic acid gas, from 1 to 1½ ounces of water, and an undetermined quantity of organic matter. This organic matter is partly solid, consisting of epithelium and fatty matter from the skin and mouth, and partly a vapour given off from the lungs, the nature of which is somewhat uncertain. It is extremely offensive, and is so imperfectly diffusible that it is probably in great part molecular; it is nitrogenous and oxidisable, although but slowly. It is readily absorbed by damp walls or bedding, the most hygro-scopic substances taking it up most readily. It is this substance that gives the fusty smell to an ill-ventilated room. Experiments have shown that it is highly poisonous, and this explains the fact that air fouled by respiration is much more deleterious than that vitiated by combustion or by the addition of pure carbonic acid gas. Parkes states that "allowing the fullest effect to all other agencies, there is no doubt that breathing the vitiated atmosphere of respiration has a most injurious effect on the health. Persons soon become pale, and partially lose their appetite, and after a time decline in muscular strength and spirits. The aëration and nutrition of the blood seem to be interfered with, and the general tone of the system falls below par." Under such circumstances convalescence is prolonged; the reparative power is less, and wounds tend to slough and become the seat of unhealthy inflammations, and the patient is more readily affected by any local or general infective process to the poison of which he may be exposed.

The special contamination of a surgical ward may arise, first, from the presence in the atmosphere of the gaseous products of decomposition; secondly, from a great abundance of the organic particles which act as the ferments in decomposition; thirdly, from the presence of dried particles of the discharges from wounds or sores; and, lastly, by the contagion of specific infective processes, whether general or local.

The gaseous products of decomposition, consisting of sulphuretted hydrogen, sulphide of ammonium, free ammonia, carburetted hydrogen, carbonic acid and many others, undoubtedly tend to aggravate the symptoms produced by the accumulation of the products of respiration; but it is impossible to separate the effects produced by the former from those of the latter, by which they must almost necessarily be complicated in a hospital ward. Parkes states that the putrefying animal matter which frequently accumulates about camps during war forms one of the principal causes of diarrhœa and dysentery; but it is only in military practice, in which large numbers of wounded must occasionally be packed closely together and their wounds neglected for want of sufficient surgical assistance, that putrid discharges could accumulate to such an extent as to develope these diseases.

Secondly, the air of a ward containing many foul wounds has been shown to contain a great excess of organic matter, but it is impossible to separate the effects produced by it from those of foul air generally.

Thirdly, microscopic examination has demonstrated the presence of dried pus cells in the air of surgical wards in addition to the epithelium always met with in inhabited rooms. It has been supposed by some that these might possibly act as the material of contagion; that they may be the bearers of contagion can hardly be reasonably doubted.

Lastly, the air of surgical wards is apt to be contaminated by the contagion of specific infective processes, such as hospital gangrene, erysipelas, pyæmia,

&c. Of the exact nature of the contagium in most of these diseases we are still ignorant. This much, however, is tolerably certain, that in most, if not all, of them the poison is particulate; it is not gaseous, and in most cases its activity can be destroyed by those chemical substances that we call antiseptics. In the vast majority of cases it occurs in conjunction with putrefaction of the discharges from the wound; and those modes of treatment which are best calculated to prevent decomposition also serve best to prevent the occurrence of infective inflammations. The observations of Burdon Sanderson, Koch, and many others, have shown that all these unhealthy inflammations are accompanied by the presence of microscopic organisms in the discharges, and often also in the lymphatic spaces near the wound; and these observers are of opinion that the micro-organisms are directly or indirectly the cause of the unhealthy process, and that infection is brought about by the actual transference of some of these living particles from one patient to another. Koch has shown unmistakeably that diseases closely resembling gangrenous inflammation, erysipelas, septicæmia, and pyæmia, as they occur in the human subject, can be artificially produced in animals, that each disease is accompanied by the presence of a distinct form of microscopic fungus, and that it can be transmitted from one animal to another by means of infinitesimal quantities of the blood or exudation fluids containing the characteristic organism. That the organisms or their germs retain their vitality after being dried has been clearly proved with regard to the somewhat analogous disease of splenic fever in cattle. This disease is due to a rod-shaped organism, the bacillus anthracis, of such size that its life-history can be accurately studied. It has been found that under certain conditions minute spores are found in the bacillus, and that when this has taken place blood containing the virus may be dried and kept in that state for years without losing its virulence. In this state it is easily conceivable that it could be disseminated by the air. It is well known that the virus of vaccinia, small-pox, and scarlet fever equally resist the effects of drying.

Another fact of equal importance, which has lately been discovered by Pasteur and Toussaint, is that the virus of splenic fever and that of a peculiar form of septicæmia, common in fowls, known as chicken cholera, lose considerably in virulence if the organisms which form their essential part are cultivated in a medium which is not suited to their growth. The converse, although not so definitely proved, is probably true also,—that the virus increases in intensity if cultivated in a medium suited to its growth and development. Such a medium for the growth of pathogenic organisms is found in the feeble tissues and unhealthy sores of patients weakened by breathing the impure atmosphere of an overcrowded ward, and it is thus that under these circumstances infective processes of intense virulence may be developed. Our knowledge of the exact nature of the poisons of erysipelas, hospital gangrene, and pyæmia, is still very imperfect; but this much is certain, that they are essentially filth-diseases, and may, if the term is allowable, be manufactured in any hospital or house, however clean or well situated, by the accumulation within it of too large a number of patients suffering from wounds the discharges of which are in a state of decomposition. It is probable that the contagia of some of these diseases are destroyed by oxidation; but, be this as it may, it is evident that a want of free ventilation must lead to a concentration of such poisons as are disseminated by the air, and at the same time the

patient's body will be rendered more susceptible to their influence as its vitality becomes lowered.

In the prevention of the effects of over-crowding we have to consider first the vitiation of the air by the patient by the natural processes of respiration and excretion; and, secondly, fouling of the atmosphere by the emanations from wounds and sores. The first of these causes of impurity is unavoidable, and it is only by providing sufficient air for each patient and changing it with sufficient frequency that its evil effects can be prevented. In determining the condition of the air of a room or ward the carbonic acid present is taken as the index of the degree of impurity, as it is easily estimated while the determination of the organic matter is almost impossible. Parkes and De Chaumont give ·6 per 1000 volumes of total carbonic acid in the air as the limit of impurity allowable. Of this about ·2 is derived from respiration and the remainder is the normal quantity present in the atmosphere. In order to maintain the air at this standard an ordinary man requires to be supplied with 3000 cubic feet per hour. This is the minimum quantity of air that will suffice for the purpose, and it would evidently be unwise to trust to this. The rule, therefore, laid down is that at least 4000 cubic feet per hour must be provided. In order that this amount of air may be obtained without exposing the patient to draughts, a sufficient cubic space must be allowed for each patient, so that if the air be changed from three to four times per hour the requisite amount may be supplied. Under exceptional circumstances 1000 cubic feet per head might thus, with good ventilation, be made sufficient; but no Surgeon would be content with this if he could obtain more; as in civil practice he always can. The rule, therefore, laid down in the construction of hospitals is that each patient shall be allotted from 1500 to 2000 cubic feet of space, the larger space being required for infectious, or surgical cases. In order to maintain a proper degree of separation of the patients each must be allotted from 100 to 160 square feet of floor. The effective height of a ward for the purposes of ventilation does not exceed 12 feet. Not only, however, is *space* required, but change of air, by proper ventilation, is equally needful. Military experience has shown conclusively that churches form the very worst possible hospitals, for in these buildings, although the cubic space per head is frequently enormous, but little provision is usually made for efficient change of air.

The second cause of vitiation of the air of a surgical ward—the emanations from wounds and sores—is more or less completely under the control of the Surgeon. If Wounds do not necessarily add to the impurity of the air of a ward, it is the decomposition of the discharges and the effluvia so developed that give rise to the evil consequences formerly so familiar to most Surgeons. Experience tends to show that if decomposition of the discharges be absolutely prevented, a case with a wound vitiates the air of a ward no more than one without; and in the present day, when the powers and properties of antiseptics are so well understood, there is never any excuse for a wound becoming a source of impurity to the surrounding air. Should decomposition be unavoidable, as it still is in many cases, it is easy to absorb the discharges in some antiseptic dressing, which will completely disinfect them as soon as they leave the patient's body. No Surgeon doubts that an accumulation of putrid wounds in a ward gives rise to unhealthy processes, such as pyæmia, septicæmia, hospital gangrene, and the like. If such diseases do arise, most are agreed

that the ward must be thoroughly disinfected before it can safely be used again. Surely it is more rational to commence the disinfection at the source of mischief—that is to say, the wound.

A sufficient cubic space, free ventilation, and clean wounds, are therefore the essentials of a healthy hospital. Attention to these three conditions, especially the last, has in many Continental hospitals reduced the death-rate to less than a quarter of what it was in former times. Care must be taken in attending to ventilation, that the free current of air is maintained both by night and day. It is from want of this precaution during night especially that much mischief often results. The importance of maintaining efficient ventilation during night, and the little danger to be apprehended from the admission of cold night air, have been so forcibly pointed out by Miss Nightingale in her *Notes on Nursing*, and are now so universally admitted, that I need not do more than add the testimony of my experience to the truth of her observations. In cold weather, also, there is so great a disposition on the part of nurses and patients to shut up wards and rooms, that the air becomes close, oppressive, and contaminated; and hence it is that erysipelas and similar diseases are so rife during winter and early spring. The "East Wind" is commonly accused of being the cause of these; and no doubt it is so, but only indirectly, by causing windows and doors to be shut, so as to exclude the cold that usually accompanies that wind, and thus rendering the atmosphere impure. It is impossible to over-estimate the importance of a free supply of pure air in lessening the mortality after operations, not only in hospitals, but equally in private dwellings. The fact has often been observed in military practice, and the recent Franco-German War brought it into strong relief—that those wounded fare best who are treated in open huts or tents, whilst those who are placed in the apparently more favourable conditions afforded by regular houses become decimated by those scourges of military surgical practice, pyæmia and hospital gangrene. It is the difference in the hygienic arrangements in different hospitals that, more than any other condition, influences the varying rate of mortality in different institutions; and it is obvious that, *cæteris paribus*, those patients will have the best prospect of recovery who are most scrupulously attended to in this respect; that no cases of operation should be placed in ill-ventilated wards, or in those that contain more than a certain percentage of patients suffering from wounds or sores, the discharges from which are unavoidably foul; and that the performance of operations in close and ill-ventilated rooms, or in houses situated in overcrowded neighbourhoods, should, as far as possible, be avoided. The faulty hygienic conditions that are still too frequently met with in hospitals, are alike a cruelty to the patient and an injustice to the Surgeon. The cruelty to the patient consists not only in exposing him to an increased chance of death—or, as it is commonly called, "to a higher rate of mortality" from septic diseases that are preventable, and that are the direct outcome of the defective hygienic arrangements of the institution—but in subjecting him to a prolonged and imperfect convalescence; either or both of which conditions may be taken as the measure of the neglect of sanitary arrangements in a hospital.

But want of attention to sanitary hospital arrangement is equally an injustice to the Surgeon. His reputation suffers by an increased rate of mortality amongst his patients from causes which, though preventable, are altogether beyond the sphere of his control; an undue burden of anxiety, responsibility, and of care is thrown upon him by the necessity under which he lies of

waging a constant warfare against septic hospital influences. If it were not for erysipelas, pyæmia, septicæmia, and "blood-poisoning" in its protean forms, the duties of a hospital Surgeon would be comparatively light.

Attention to hospital hygiene is by no means of so modern a date as many appear to suppose. The Surgeons of the last century paid great attention to it, and their success was proportionately great. Thus Alanson's success in amputations has never been surpassed, and rarely, if ever, equalled even by the aid of antiseptics and of every modern chemical and mechanical appliance. Writing in 1782 ("Alanson on Amputation and the After-treatment," London, 1782), he says (Preface, p. 15), that he amputated in thirty-five cases, such as promiscuously occurred in the Liverpool Infirmary, *without the loss of a single patient.* The symptomatic fever was slight, and there was not an instance of secondary hæmorrhage in the whole series. Alanson was a sanitary reformer in his day; and had his instructions been followed, thousands of lives would have been saved which have since his time been wantonly sacrificed by the neglect of hygienic measures. His advice is so practical that it deserves the attentive study of the modern Surgeon. He says: "The air in which the case is to be conducted is a point worthy of your greatest attention: if possible, the room should be spacious, and in an open wholesome situation. It is well known that in hospitals which are situated in populous towns and are much crowded, the salutary influence of the air is so altered, that compound fractures and other important surgical cases prove peculiarly fatal, and that such fractures may almost certainly be cured in the country." . . .

"The operation of amputation done in the country, as above described, will be followed almost certainly with a speedy cure; there the consequent symptoms are trifling, nearly the whole internal surface of the wound unites by the first intention, the suppuration consequently is small." . . .

"Many hospitals are so tainted by unwholesome effluvia that they are rather a pest than a relief to the objects they contain." (Op. cit., p. 89—92.)

Then follow sixteen distinct paragraphs or heads of the most useful sanitary advice, which "are humbly recommended to those who have the care of hospitals in want of such attention."

This code of regulations deserves careful study. In it Alanson advises:

That no ward should be inhabited for more than four months at a time: that it be cleansed, whitewashed, and purified. That the "bed-stocks" be of iron; the bedding frequently changed, and made of inexpensive materials so that it may easily be renewed; and that when the weather admits, it be exposed to the open air for several hours a day. That dirty patients be stripped of their clothing before admission; that they have a warm bath and then be clothed in dresses provided by the hospital. That the infected clothes be baked in a properly constructed oven. That newly admitted patients be put into clean, well-ventilated wards. That all incurable and infectious cases, and especially chronically ulcerated legs, be refused admission. That offensive gangrenous and putrid sores be placed in distinct rooms, and not suffered to infect a whole ward. That there should be particular rooms provided for patients who have undergone operations; that they should be airy, never long inhabited, and afterwards cleansed and ventilated. That a hospital should never be crowded *on any account*, and always so large that a part may be uninhabited. That the windows be opened for a certain number of hours daily. And lastly, that every hospital should have a "house in the country,"

in other words, a "convalescent home," attached to it. Modern science has enabled us to determine the true nature of those conditions that lead to hospital infection, but sanitary practice has not as yet gone in advance of the admirable precepts laid down by Alanson a century ago.

The mortality arising from inattention to these various hygienic conditions, whether want of cleanliness in the wound or want of pure air in the ward, is not a necessity of the operation, but rises and falls according as the treatment of the wounds, or the circumstances in which the patient is placed, depart more or less widely from those conditions that are necessary to the maintainance of health. The frequency of the occurrence of erysipelas in an institution may be taken as an indication of neglect in its sanitary arrangements. Pyæmia and septicæmia as a rule indicate in addition to general neglect, a want of cleanliness in the wounds, and reflect to a certain extent upon the Surgeon as well as the institution. These diseases are preventable, and ought to be prevented. Surely the first and most essential requisite of a hospital is that it be not a source of disease to its inmates—that those who are compelled to seek its aid shall not suffer from its effects.

The exposure of a patient after an operation to the *contagious emanations* of septic diseases from other sick or wounded patients, is attended by the most fatal consequences. Whenever it is practicable, every case of septic disease, such as pyæmia, erysipelas, inflamed absorbents or veins, or hospital gangrene, should be rigorously excluded from the ward or room in which other patients with operation-wounds happen to be lying; and, if possible, the same nurses, dressers, or surgeons should not be allowed to go from the infected to the healthy, nor should the same appliances, dressings, or sponges be used for both.

When this is not possible, the danger of infection may be greatly diminished by the free use of antiseptics to the wounds both of the infected and the healthy.

Great care also should be taken in the purification of the bedding that has been used by patients suffering from septic disease; the blankets especially are apt to harbour infection long, and must be thoroughly purified. Every hospital Surgeon must have had abundant occasion to deplore many deaths after operation, arising from preventable causes due to want of attention to these simple precautions.

3. The **Special Conditions directly excited by the Operation itself**, predisposed to by the circumstances that we have just been considering, and which commonly lead to a fatal result, of which they are the immediate occasion, are the following:—Shock, Exhaustion, Hæmorrhage, Gangrene, Tetanus, Pyæmia, Septicæmia, Erysipelas, and other Diffuse Inflammations. These causes of death are so various, and comprise so many distinct diseases, that I shall do little more here than mention them; referring the reader to the different chapters in the body of the work, in which each is specially treated.

The *Shock of an Operation* may prove fatal in various ways: from the severity of the mutilation, as in a case of double amputation: from the nervous centres being implicated, as in the removal from the face of large tumours that have connections with the base of the skull; from fear, or from the state of nervous depression, into which the patient has previously fallen, causing him to feel the influence of an operation disproportionately to its

severity. These various effects of shock have, however, been much lessened since anæsthetics have been generally administered in operative surgery. Anæsthesia, however, does not remove the physical impression produced on the system by a severe mutilation; hence the influence of a serious and prolonged operation is still manifested in the production of shock, of collapse, and of slow recovery, even though the patient have suffered no actual pain. Certain operations appear to exercise a peculiar, depressing effect on the nervous system, even though no pain be experienced. Thus, in castration, at the moment of the division of the spermatic cord, the pulse will sink markedly, even though the patient have been fully anæsthetised. So much is this the case, that it is well at that moment to suspend the administration of the anæsthetic.

Exhaustion, without any tangible local or constitutional disease, is an occasional cause of death after severe operations; more particularly in delicate females, in feeble or debilitated subjects, in those who have lost much blood, or who have become weakened by protracted suppuration. A large number of the deaths formerly recorded as due to exhaustion were doubtless the effect of slow poisoning from the absorption of putrid matter from unclean and imperfectly drained wounds.

Hæmorrhage, if very copious, may destroy the patient by inducing syncope that may be immediately fatal; or by increasing the influence of the shock so that he cannot rally; or, by weakening him and lowering his vitality, it may render him more liable to be affected by unhealthy inflammations and septic processes, which frequently terminate fatally.

During the performance of an operation, hæmorrhage should, as much as possible, be prevented; the operation itself is a cause of depression, and any great loss of blood seriously aggravates this. It is in these secondary and indirect effects that the great danger of excessive hæmorrhage lies. Blood is a very complex fluid; if once lost it is not easily replaced, more especially in advanced years. At any period of life, its excessive loss may permanently impair the constitutional powers. Patients who have lost much blood make slow recoveries, often interrupted by intercurrent diseases; and not unfrequently die at the end of two or three weeks, from some visceral complication. In fact, it is in this way, rather than from its immediately dangerous consequences, that the loss of a large quantity of blood at an operation proves injurious to the patient. When hæmorrhage occurs a few hours, or a day or two, after an operation, it usually proceeds from imperfect ligature of the vessels, or from arteries bleeding after the setting-in of reaction, which had not furnished blood whilst the patient was under the influence of the shock of operation. On recovery from anæsthesia also, it not unfrequently happens that arteries begin to spout, which yielded little or no blood whilst the patient was in a state of anæsthesia. In these circumstances, hæmorrhage is of far less moment, and less frequently fatal, than when it occurs at a later period, in consequence of some morbid condition of the wound, and frequently in association with local diffuse inflammation or general infective processes.

Gangrene is not a common cause of death after operations, except in the phagedænic form in military practice in time of war. When it occurs in civil hospital practice, it is the result, in most cases, of faulty but preventable hygienic conditions; and its frequency in any institution is the direct measure of, and of itself a conclusive proof of, neglected or defective sanitary

arrangements. In the local form it may, however, occur without being the result of want of hygienic precautions, from purely local conditions, as in a limb from excessive traumatic violence, or in a strangulated hernia in consequence of prolonged strangulation of the gut before operation.

Tetanus but rarely occasions death after operations in this country. When it does occur, it is more frequently after the lesser than after the greater operations that it developes itself.

Internal Inflammations of an acute and active character may carry off the patient after an operation in two ways. Inflammation of this kind may have existed antecedently to the operation, being the disease for which it is performed; and, being unchecked by the operation, may continue its course and destroy life. Thus, when a child dies after tracheotomy for croup, death is not in general occasioned by the operation, but by the extension into the lungs of the disease for which it has been performed. Or the inflammation may be the consequence of the operation; as when peritonitis occurs after the operation for strangulated hernia, or meningitis after the skull has been trephined. But it is not by the action of any of these direct results that an operation usually proves fatal. In the great majority of instances, death is occasioned in a more indirect manner by the development of pyæmic or erysipelatous inflammations, to which a neglect of hygienic laws acts as a powerful predisposing cause.

Septic disease, in one or other of its forms, was certainly the most frequent cause of death after operations, more particularly in large towns. Closely allied to pyæmia and septicæmia, frequently co-existing with them, and having the same predisposing causes, are the various *diffuse inflammations,* whether assuming the form of erysipelas, of phlebitis, or of inflammation of the absorbents, which are the dread of surgeons and the scourge of hospitals. It was to pyæmia, and to these various allied processes, that at least three-fourths of the deaths after operations were formerly due. This proportion has, however, been greatly reduced of late years by improved methods of treating wounds, and greater attention to the sanitary arrangements of our hospitals. It is in the production of these diseases that an impure blood, loaded with effete materials, retained through habitual disregard of the ordinary rules of health or through defective elimination by the kidneys and skin, acts as a potent predisposing cause. In these circumstances, it is not the extent of the wound that determines the dangerous results. A mere breach of surface, however trivial, is sufficient to form a starting point for these morbid processes. In such conditions of the system, the amputation of a toe may be as fatal as that of the thigh, or the removal of a small atheromatous cyst of the scalp as the ablation of the breast; the only additional danger essentially connected with the greater operations being the increased risk from shock and hæmorrhage.

Diphtheritic Inflammation may develope in a wound with or without concomitant throat-affection. It may be developed by direct contagion, or under the influence of those local epidemics or constitutional influences that cause diphtheria to appear in the fauces. When a wound becomes affected in this way, the edges and the integument for some little distance around are swollen, brawny, and of a deep red colour; the surface of the wound is covered with a greyish white exudation which cannot be cleaned off; and febrile symptoms of a low type develope themselves.

PREPARATION FOR OPERATION.

The Surgeon, being convinced of the necessity of having recourse to an operation, should fully and unreservedly lay before his patient the state of the case, and, if necessary, give the reasons that render it imperative, in order to obtain his consent and that of his family. In the event of the patient refusing to submit, what course should the Surgeon pursue? In this he must be guided partly by the nature of the proposed operation; and partly by the state of the patient, and his capability of forming a correct judgment of his case. If the operation be one of expediency, merely for the relief of an infirmity or the removal of an ailment which does not directly jeopardise life, most certainly no Surgeon would think of undertaking it without the full consent of his patient. If, on the other hand, it be an operation that is imperatively necessary for the preservation of life, in which the delay of a few minutes or hours may be fatal to the patient, as in one of the four cases of extreme surgical urgency, viz., dangerous hæmorrhage, asphyxia, over-distended bladder, or strangulated hernia, and where the patient, unaware of, or incapable of being made to understand, the necessity for immediate action, is unwilling to assent to the proposal, the Surgeon will truly be placed in a dilemma of anxious responsibility—between allowing the patient to fall a sacrifice to his obstinacy, ignorance, or timidity, and attempting, perhaps unsuccessfully, to rescue him without his own consent from inevitable death. I believe the proper course for the Surgeon to pursue under such circumstances, is to judge for the patient in a matter on which he is clearly unable to form an opinion, and to compel him, so far as is legal and practicable, to submit to the necessary steps for the preservation of his life, or to put him under anæsthetics, and, when he is unconscious, to perform any operation that may be necessary. In the event of the patient being insensible, as after an injury of the head, the Surgeon must necessarily take upon himself to act as the case requires. Children cannot be considered capable of giving an opinion as to the propriety of an operation; the consent of the parents is here necessary, and quite sufficient; and, in their absence, the case being an urgent one, the Surgeon must stand *in loco parentis*, and take all responsibility upon himself.

These points having been determined, the patient should, if possible, be *Prepared for the Operation.* In a great number of cases requiring operation, as strangulated hernia, bad compound fracture, &c., no time is allowed for preparation, but the Surgeon must at once submit the patient to the knife, whatever the state of his constitution may be. But in the more chronic cases, time is given for improving the constitution. This preparation must not consist in any routine system of purging and starving, which is ill calculated to support the constitution against the call that will be made upon its powers; nor, on the other hand, in blindly adopting a tonic or stimulating regimen; but in adapting our means to the condition of the patient and the nature of the operation to be performed. The tendency to erysipelas, pyæmia, and diffuse inflammations generally, is materially lessened by supporting the patient's strength, by means of a nutritious diet, previously to the performance of the operation. Indeed, in many of the more severe injuries and surgical diseases, it is only by the use of a nutritious diet, and by the administration of tonics, quinine, or iron, and stimulants, often in large quantities, that the patient can be brought into a condition to bear the shock and consequent depression of the operation. This is more particularly the case with hospital

patients of bad constitution, who have met with serious accidents, followed by much suppuration and fever. In the more chronic cases, the time should be seized for the operation when the temperature of the body is not too high, when the secretions are free, the tongue clean, and the action of the skin and kidneys healthy; and, above all, the mind should be kept tranquil and hopeful, being allowed to dwell as little as possible upon the impending event. In many operations, as those on the rectum and urinary organs, or in those of a plastic character, special modes of preparation are required, which will be discussed when we come to treat of the operations in detail.

The Surgeon himself must always feel the heavy responsibility that hangs over him during the performance of a great operation—"at that moment when," as Dr. Grant has elegantly said, "Death everywhere surrounds his knife as he is endeavouring to convey all his knowledge to its point." But having carefully considered each successive step of the operation, provided for every emergency that can by any possibility arise in the course of it, and trusting in Him, from whom all knowledge is derived, to strengthen his judgment and guide his hand aright, he will proceed to the performance of his duty with self-reliance, and in the full confidence of being able to effect all that Art can accomplish.

EMPLOYMENT OF ANÆSTHETICS.

It is reasonable to believe that the prevention of pain in surgical operations has been an object of solicitude to Surgeons, as well as to patients, from the earliest ages: and narcotics of various kinds have at different times been employed with this view. But the effect of these was so uncertain—their after-consequences perhaps so injurious—that no permanent reliance was placed upon them. The first endeavour to induce anæsthesia by the inhalation of vapours is stated to have been made in the thirteenth century by Theodoric, who recommended that a "Spongia Somnifera," impregnated with spirituous extracts of various narcotic substances, should be held to the nostrils till sleep was induced; and that after the operation the patient should be roused by the use of vinegar or fenugreek. It was not, however, till the commencement of this century that any serious attempts were made in this direction. The discovery of the remarkable properties exercised on the nervous system by the inhalation of nitrous oxide, then led Sir Humphry Davy and others to entertain hopes that it might be used as a means of relieving pain during surgical operations. Experiments were made with the gas with this view, but they did not prove altogether satisfactory, and its administration was abandoned, except as a means of amusement.

It is needless to do more than allude to such means as the compression of the nerves of the limb, as recommended by Moore—the employment of excessive venesection, as adopted by Wardrop—or the production of insensibility by mesmerism by Esdaile and others. These means of inducing anæsthesia were either inefficient, dangerous, or chimerical.

It was not until 1844 that a serious attempt was again made to introduce insensibility by inhalation during operations: and to the Americans is undoubtedly due the honour of having established the practice of Anæsthesia in Surgery. In that year Horace Wells, a dentist of Hartford, Connecticut, inhaled the nitrous oxide gas with a view of rendering himself insensible during the extraction of a tooth; and, finding the experiment succeed, re-

peated it on several of his patients. Its success was not, however, constant; and having failed in several cases, he seems to have given up the attempt. In 1846 Dr. Morton, a dentist, and a pupil of Wells, used the vapour of ether instead of the nitrous oxide gas; and, having succeeded in extracting several teeth painlessly, applied to the authorities of the Massachusetts General Hospital at Boston for permission to administer it to a man from whom Dr. J. C. Warren was about to remove a tumour of the neck. The result was most successful. The news of this great discovery was immediately sent to England, where the first operations on patients anæsthetised by the inhalation of ether, were performed at the University College Hospital by Liston, who amputated a thigh and tore out an ingrowing toe-nail without any suffering to the patient. At these operations I was present; they were performed on Dec. 22, 1846; and from that time the use of anæsthetics has been established in surgical practice in every civilised country.

For more than a year, sulphuric ether was the only agent habitually used for inducing anæsthesia. But during the whole of this period many professional men were busy with experiments on the anæsthetic influence of various kinds of vapours; and in November, 1847, Professor Simpson, of Edinburgh, published an account of the anæsthetic properties of chloroform. In this country this agent soon came to be generally employed, although ether held its ground with the American surgeons, by most of whom it has always been preferred to chloroform.

The employment of *Anæsthetics* in Surgery is undoubtedly one of the greatest boons ever conferred upon mankind. To the patient it is invaluable in preventing the occurrence of pain, and to the Surgeon in relieving him from the distress of inflicting it. Anæsthesia is not, however, an unmixed good. Every agent by which it can be induced produces a powerful impression on the system, and may occasion dangerous consequences when too freely or carelessly given; and, even with every possible care, it appears certain that the inhalation of any anæsthetic agent is in some cases almost inevitably fatal. We cannot purchase immunity from suffering without incurring a certain degree of risk from the very agent which gives us ease. There can be little doubt that many of the deaths that have followed the inhalation of Anæsthetics have resulted from want of knowledge or of due care on the part of the administrators; yet, whatever precautions be taken, there is reason to fear that a fatal result must occasionally happen. This immediate risk, which is very small, is more than counterbalanced by the immunity from other dangers which used formerly to occur during operations.

There is, however, another question in relation to Anæsthetics which deserves the most serious consideration on the part of the Surgeon; viz., Do they influence the rate of mortality after operations? On this point there is conflicting testimony. Simpson has published statistics to show that the mortality after operations has lessened since the introduction of chloroform. J. Arnott, on the other hand, adduces figures to prove that it has materially increased, in amputation by 12, in lithotomy by as much as 28 per cent. I am inclined to believe that the rate of mortality has increased since the use of Anæsthetics in operative surgery. But is this increase altogether, or indeed to any degree, due to any effect produced on the system by the inhalation of Anæsthetics? Is it not in reality rather the indirect than the direct result

of the employment of Anæsthetics? May it not, in some measure at least, be owing to operations being often performed in very doubtful or extreme cases, now that they can be done painlessly, when formerly the suffering inflicted would have deterred the Surgeon from proposing, or the patient from acceding to, their performance? A surgical operation was formerly, from the pain attending it, looked upon as a more serious affair than it is at the present day, and surgeons were not willing to inflict suffering unless there were a good prospect of a successful issue. Now, however, that the most serious operations can be performed without any consciousness of suffering, the Surgeon, in his anxiety to give his patient a chance of life, may not unfrequently operate for disease or injury that would otherwise necessarily and speedily be fatal, and which formerly would have been left without an attempt at relief. But there is another cause that may account for this increased rate of mortality. During the first thirty years after the introduction of Anæsthetics, the actual number of operations performed in hospitals enormously increased, probably in a great measure owing to their employment. Hence hospital wards became more crowded than formerly with severe operation-cases, and the causes of septic diseases became much more rife, those diseases more frequent, and the mortality proportionately augmented. At the present time, owing to improved treatment of wounds, and better sanitary arrangements, the mortality after operations is lower than it has ever been before.

Making, however, all allowance for the extension of operative Surgery to extreme cases that were formerly not thought to come within its range, I cannot but think that chloroform does exercise a noxious influence on the constitution, and does lessen the prospect of recovery in certain states of the system, more especially when the blood is in an unhealthy state. In such circumstances, the depressing influence of chloroform appears to me to act injuriously; the patient does not rally well after the operation, and immunity from suffering is purchased by a lessened chance of recovery.

Anæsthesia by the Administration of Chloroform is best commenced before the patient leaves his bed. The chloroform should never be given but by a person accustomed to its use, and on whose capability the Surgeon has full reliance; as nothing is more embarrassing during an operation, than to have any doubt about the chloroform being properly administered. It must not, however, be imagined that it can be safely given only by a specialist. Every student before leaving the hospital may easily make himself sufficiently acquainted with the details of its administration to enable him to give it with perfect safety, provided he pays undivided attention to what he is doing and does not allow his mind to be diverted by watching the operation or by attempting to act both as anæsthetist and assistant. Before administering any anæsthetic, the patient should be asked if he wears false teeth, and if so, they should be removed. Any article of clothing about the neck, chest, or waist, that might cause interference with respiration or circulation must be relaxed, and the patient then placed, if possible, in the recumbent position. Chloroform may be administered in many different ways, either on lint or on a handkerchief, or through an inhaler of some kind. The following is the way in which chloroform may most safely be given on lint or a handkerchief, without apparatus of any kind. On a piece of folded lint, about three inches square, and consisting of three doubles, about a drachm of chloroform is poured; and the lint is then held at a distance of about three inches from the nose of the

patient, so as to permit a very free admixture of air with the first few inhalations of the vapour. After the lapse of about half a minute, the lint is brought nearer to the patient's nose, to within a distance of perhaps an inch, being never allowed to touch—for, apart from any other danger, it may blister the skin ; at the same time a porous towel, not doubled, is lightly laid over the face of the patient and the hand of the operator, so as to limit the escape of the chloroform-vapour, but not to prevent the admission of air. During the whole time, it is the duty of the administrator to keep his hand on the pulse, to watch the breathing, and occasionally to examine the pupils of the patient.

The method just described has been shown by experience to be one of the most practically useful modes of administration, and to be quite as safe as any other. A committee of the Medical and Chirurgical Society of London, which reported on the administration of chloroform in 1864, determined that $4\frac{1}{2}$ per cent. is the maximum amount of the vapour which can safely be mixed with the air the patient inhales. Lister has shown by experiment that the proportion given off from a folded piece of lint, used as above described, is far below this, and there is therefore no necessity for the use of the complicated and ingenious inhalers which have sometimes been recommended. Mr. Clover, to whom we are indebted for the most accurate and scientific of these instruments, used it himself many thousands of times without an accident of any kind ; but it is highly probable that so careful and skilful an administrator would have obtained equally good results had he used merely a piece of lint as above described. Whatever leads the administrator to rely upon anything but careful and continuous observation of the symptoms of the patient is an evil in the administration of chloroform, and all inhalers have a tendency to do this. The only merit that can be claimed for any form of inhaler is that the mixture of chloroform and air given is of constant strength, whereas, when administered on lint, the vapour given off is most powerful immediately after the lint has been wetted with the anæsthetic, and gradually diminishes in strength as the administration continues. This may be obviated by the following plan, which is now recommended by Lister in the place of that he formerly advocated. Put one corner of a stiffish towel over the face in such a way that the point is over the chin ; opposite the forehead gather up the towel in three or four puckers, and, if necessary, pass a pin through them ; there is thus produced a concave mask, which covers tolerably accurately the mouth and nose. By allowing a drop or two of chloroform to fall upon it from a drop-bottle every few seconds, the central part is kept constantly wet over an area about two inches in diameter. By this means a dose of practically constant strength can be easily administered.

The principal points to be attended to during the inhalation of this potent agent are, that it be not given too suddenly, nor in too concentrated a form; and that, whilst under its influence, the patient be not raised into the erect or sitting position. If lint be used, it may be too much saturated, and be held too closely applied to the mouth and nostrils, so that the patient may not be able to get sufficient air, and may speedily become partially asphyxiated, choking violently, struggling to get free, and becoming purple in the face. Care should be taken not to compress the abdomen in holding the patient ; for, as the respiration becomes chiefly or wholly diaphragmatic, it may be seriously interrupted by any pressure on the abdominal

wall. Whilst under the influence of chloroform the patient should never be raised up, as has just been stated; for, as this agent exercises a powerful sedative action on the heart, sudden and perhaps fatal syncope may ensue from putting the patient into the erect position. Hence, also, it is dangerous to administer it in those operations that require to be performed whilst the patient is erect. It should never be administered, except in cases of great emergency, to a patient who has eaten anything within three or four hours, lest it induce vomiting of the partially digested meal. On the other hand, the patient should not be exhausted for want of food, as may happen if the operation be performed early in the morning. Thus, if 9·30 be the hour fixed, he should have a cup of strong beef-tea, or a raw egg beaten up in tea, or some such light and easily digested nourishment at 6·30 o'clock. With due caution, it may be given with perfect safety to individuals of all ages. I have operated on infants less than a week old, as well as on octogenarians, under its influence. In administering it to young children, Snow recommended its dilution with rectified spirit, but this is unnecessary.

The effects of the administration vary considerably with different patients. Occasionally the patient becomes unconscious as quietly as in the natural process of going to sleep. More commonly the first sensation produced is a feeling of warmth at the pit of the stomach. This is followed by some choking sensation and violent beating of the heart, with noises in the head. At this period the patient begins to lose self control. He talks excitedly, but not absolutely incoherently, and the struggling which frequently takes place assumes the form of efforts to remove the chloroform from his face, or to escape from the hands of the Surgeon and his assistants. At this time the pulse is quicker and more forcible than natural, the respiration is hurried and deep, the pupil acts readily to light, the face becomes flushed, and if the struggling is violent, it may become purple and turgid. The patient frequently remembers the struggle with the administrator during this stage, and the Surgeon and his assistant should avoid any unguarded expression which might leave on the patient's mind an idea that he was roughly used. This period of excitement is quickly followed by loss of consciousness. The struggling may still continue, but the movements are purposeless, and such words as he utters are disconnected and incoherent. At this stage, a violent tonic contraction of every muscle in the body may take place; respiration is arrested, and the face becomes dusky. It is wiser not to force the chloroform when this condition is present. If the lint be removed from the face for a few seconds the spasm ceases, and a few good deep respirations remove the lividity of the face, when the administration may be recommenced without danger. More commonly the stage of excitement is followed directly by that of complete insensibility, a few deep, hurried respirations separating the two. The face now becomes pale but not livid, the respiration is regular, slow, and shallow, the pulse falls in frequency and force, all the voluntary muscles become flaccid, and reflex movements can no longer be induced by pinching the skin or touching the conjunctiva. The pupil is at first contracted, but afterwards becomes widely dilated and insensible to light; and this is a sign that the administration has been pushed to the furthest limits consistent with safety, and must be suspended till the pupil again responds to light. Immediately before this stage is reached the patient may snore loudly; but in deep anæsthesia, the respiration, being slow, shallow, and chiefly diaphrag-

matic, is usually not sufficiently violent to produce any sound. What may be called the healthy snoring of deep anæsthesia must be distinguished from the loud inspiratory stertor indicative of spasmodic closure of the glottis. The latter is a sign of danger and necessitates the immediate removal of the chloroform until the spasm has passed off and has been followed by three or four healthy respirations. When fully anæsthetised, the patient is at the verge of death, and requires the most careful watching by the person who administers the chloroform; his fingers should be kept constantly on the temporal artery, as the most convenient point for feeling the pulse, and his eyes should not be taken away from the countenance of the patient. He must watch, on the one hand, for lividity indicative of impending asphyxia, and on the other, for pallor showing feebleness of the heart's action. The breathing must be carefully observed, and the administrator must not be content with seeing that the movements of respiration continue, but must feel with his hand that air is actually passing in and out, as in spasmodic closure of the glottis the respiratory movements continue regularly for some time after air has ceased to enter. Many accidents doubtless arise from the patient being thus allowed to become partially asphyxiated, and the heart's action greatly enfeebled; and when, as usually happens, the spasm passes off and is followed by a deep inspiration, instead of pure air, which is so greatly needed, a concentrated dose of chloroform vapour is supplied, which suddenly checks the action of the weakened heart.

If the inhalation of chloroform have been suspended, great care should be taken when its administration is recommenced, lest the already enfeebled heart be entirely overpowered by the influence of a volume of vapour suddenly given in a concentrated form.

It should be borne in mind that it is not necessary in all operations to administer chloroform to the same extent. In all the greater operations, as amputations, lithotomy, and the ligature of arteries, enough should be given to completely paralyse muscular movement, as well as to suspend sensibility and consciousness. In operations for hernia, also, and all other proceedings implicating the abdominal walls, if complete muscular relaxation be not induced, great inconvenience and not a little danger may result. So, also, in very painful operations about the anus and genital organs, a full dose of chloroform should be given. But for the removal of many tumours about the trunk, or in many of the minor operations on the extremities and about the head and face, muscular relaxation is not so necessary; and it will be sufficient to give enough chloroform merely to suspend sensibility and consciousness to pain.

Death from Chloroform may occur in three different ways; viz., by *Coma*, by *Asphyxia*, or by *Syncope;* through the brain, the lungs, or the heart.

When death occurs by *Coma*, the patient is heard suddenly to breathe stertorously; he becomes livid in the face, and is convulsed; the heart beats until the last moment of life, and death appears to result primarily from the circulation of dark blood through the nervous centres. This form of death occurs chiefly in individuals who are epileptics, or who are suffering from advanced kidney disease.

Death by *Asphyxia* may be produced in three ways. 1. It may be the fault of the administrator, sufficient air not being admitted with the chloroform-

vapour to maintain the respiratory function. This is especially apt to happen when a patient, being semi-narcotised, has a piece of lint saturated with chloroform suddenly applied to the mouth and nose, the heat of the operator's hand and of the patient's body rapidly producing a large volume of vapour. 2. Lister describes the production of asphyxia as being due to spasmodic closure of the upper opening of the larynx, the folds of mucous membrane above the apices of the arytænoid cartilages being carried forwards till they are in contact with the base of the epiglottis, which remains erect and unchanged in position. This theory was founded on observations of the larynx during the production of that peculiar laryngeal stertor which usually precedes the stoppage of the respiration. On pulling the tongue forcibly forward, the arytænoid cartilages were seen to be drawn backward, and the opening of the larynx made perfectly free again ; and this seemed to be due to reflex action and not to the mere mechanical act of drawing the tongue forwards. This is quite possible during anæsthesia, as the reflex functions of deglutition and respiration are not affected by chloroform as administered for a surgical operation. The closure of the glottis may often pass unnoticed till the pulse stops, as the heaving of the chest may go on for some time after air has ceased to enter ; the only signs of the state of the patient being the gradually increasing lividity of the face, and the fact that no air is entering or coming out during respiration, which can be ascertained by feeling with the hand over the mouth. Lister is of opinion that many of the deaths from chloroform, in which the heart has been said to stop first, were cases of this kind. He insists on the necessity of pulling the tongue forcibly forwards with forceps, and not merely drawing it out in front of the teeth, if the spasm is not immediately relieved by the simpler process recommended by Clover of pulling the chin strongly upwards. 3. Asphyxia may also be caused by the impaction of half-digested food in the larynx during vomiting, and false teeth have also been known to slip into the larynx during the administration of chloroform, and the same accident has happened with the gag used in dental operations.

In death from *Cardiac Syncope*, the patient, after a few inspirations, suddenly becomes pale and faint ; the pulse beats in a flickering manner a few times and then ceases, though respiration may continue : the fatal event being evidently due to paralysis of the heart. This is an accident that may occur to individuals who are depressed either by mental emotion or by physical debility before taking the chloroform ; and it is not unfrequently connected with a fatty heart. It is best guarded against by giving the patient a little stimulant, as brandy or ammonia, before commencing the inhalation.

In some cases death has occurred from syncope suddenly at quite an early stage of the administration, and when a small quantity only has been given, without any morbid condition being discernible on examination of the body after death. It seems possible to explain such cases only by supposing that in rare instances there exists an idiosyncrasy, owing to which a small quantity of chloroform acts directly upon the heart. Lister records a case of exactly the opposite condition, in which the patient seemed incapable of being affected by even the largest doses.

Secondary Effects of Chloroform may develope themselves in connection with the *head*, the *lungs*, or the *stomach*. The liability to inconvenient secondary effects depends chiefly on two conditions : 1, on the mode of administration of the chloroform, especially on the care taken that there is an adequate supply of

air admitted at the time when the vapour is inhaled; and 2, on the state of the patient as to age, habit, temperament, and digestion. Old people, habitual spirit-drinkers, and those of a bilious and sanguine temperament, are apt to suffer most. The condition of the digestion is of great importance. If chloroform be given too soon after a meal, injurious results are sure to follow; hence, it is best administered on an empty stomach.

Head-Complications follow the administration of chloroform chiefly in the aged. In them headaches and stupor not unfrequently supervene, and occasionally paralytic or apoplectic symptoms will develope themselves some days after the anæsthesia. In young and nervous women hysterical symptoms often appear, and continue for some hours or even days; but they need not excite uneasiness.

The *Lungs* probably always become slightly congested during the administration of chloroform. But, as recovery takes place, and the respiratory process is naturally re-established, the pulmonary vessels unload themselves, and no inconvenience results. The process is greatly facilitated, and the effects of chloroform are readily got rid of, by desiring the patient to breathe several times fully and deeply after consciousness returns. In some cases the lungs do not unload themselves of the accumulated blood; and a process of slow asphyxia may set in, and may prove fatal in a period varying from twenty-four hours to four or six days. This is a frequent occurrence in old patients suffering from chronic bronchitis and emphysema, and is not an uncommon cause of death after operations for strangulated hernia, as the strangulation is frequently caused by violent straining in coughing. It is also especially apt to happen in those cases in which it becomes necessary to bandage the chest, or in which deep respiration is attended by pain, as after amputation of the breast. Great care must, therefore, be taken not to constrict the chest-walls too tightly after such operations.

Irritability of the Stomach, attended by continual nausea and vomiting, is sometimes a very distressing after-effect of chloroform, and may be productive of most serious and even of fatal results. It is less likely to occur if the patient can be left undisturbed and allowed to sleep off the effects of the chloroform. In many instances it is developed by the patient taking the chloroform too soon after a meal, and is then purely gastric, and usually occurs early in the administration. In other instances it appears to be sympathetic with cerebral disturbance of some kind; in other instances, again, it is connected with kidney-disease. But in any case, and from whatever cause arising, it is a very serious symptom, and, if it continue, often turns the scale against the patient by the exhaustion to which it gives rise. It is best treated by ice or weak iced brandy and sodawater. Strong, iced, black coffee with bromide of potassium is occasionally useful, and in extreme cases a mustard plaster, or even a blister, to the epigastrium may be tried.

In certain diseased conditions of the system the administration of chloroform requires much care; but, as a general rule, it may be stated that, whenever the constitutional disease has not advanced to such a degree as to contra-indicate an operation, chloroform may be given. In the early stages of phthisis it may usually be safely inhaled; but in some cases of bronchial irritation, the vapour is apt to produce troublesome cough. When the heart is diseased, great caution is necessary, more particularly when its muscular substance has undergone fatty degeneration; the sedative influence of the chloroform being apt, in these

circumstances, to produce a sudden depression or arrest of the heart's action. In many, perhaps the majority, of the cases of death from chloroform, the fatal event has been traced to this cause. In valvular disease of the heart, I believe that it may be more safely given. In persons who are epileptic, and in those who suffer from congestion of the brain, it requires to be cautiously administered, as in the early stages of anæsthesia much cerebral excitement is apt to be evinced. In hysterical subjects, chloroform is said to induce a tendency to laryngeal spasm. The most dangerous condition in which to administer chloroform is advanced renal disease ; in such cases epileptiform convulsions are readily induced, with lividity of the face, and a tendency to stertor and coma.

Should chloroform, or any anæsthetic, be given in operations rendered necessary by severe injuries, *during the continuance of the shock of the accident*, as in primary amputations ? In such circumstances, its use has been objected to on the ground that it would act injuriously by still further lowering the already depressed vital powers ; and that the pain of the operation, if performed without it, would prove a good stimulant, and thus serve to rouse the patient. But would this really be so ? Is the pain of an operation a stimulant ? In order to answer this question, let us observe the condition of a patient immediately after the performance of a severe operation—as an amputation—without his having been anæsthetised ; and we shall find that, so far from having been restored or stimulated, he will have been seriously depressed by it. The pulse will be small, feeble, and slow ; the surface cold ; and the mind, perhaps, scarcely conscious : in fact, though a slight degree of pain, as a pinch or a prick, may act as a stimulant, very severe suffering is a most powerful depressing agent, capable in itself of destroying life. The pain of an operation performed soon after the occurrence of a severe injury, so far from rousing the patient, appears to me to act most injuriously, by inflicting a second shock upon the system before, perhaps, it has fairly recovered from the depressing effects of the first ; and it is by preventing this that chloroform is of such inestimable advantage. In these cases, it is not necessary to give chloroform to an extreme degree of anæsthesia. It is requisite to give it only to a moderate extent, chiefly so as to benumb sensation during the incisions made through the skin. After this, and during the later stages of the operation, the inhalation may be suspended entirely, or nearly so. It is an interesting physiological fact, that the physical effect of shock is produced on the system even though the patient be completely anæsthetised. This is particularly noticeable in cases of castration in which, at the moment when the cord is cut, the pulse will be found to fall several beats or to stop momentarily, even though the patient be quite insensible. Hence, it may be argued that, although anæsthesia saves the patient that amount of shock which arises from pain, it does not relieve him of that which results from the physical impression produced on the system by a severe mutilation.

The administration of Ether may be effected by the application over the mouth and nostrils of a hollow sponge saturated with the best washed sulphuric ether ; but it is far better to employ some form of inhaler, as from its extreme volatility, unless some means are taken to economise it, the quantity required becomes a serious inconvenience. When given by means of a sponge, Warren recommends anointing the face with some protective unguent to prevent the pungent effects of the ether on the skin.

Amongst the numerous inhalers which have been invented of late years,

Clover's smaller apparatus is perhaps the best (Fig. 1). It consists of a face-piece to cover the mouth and nose, to which is attached by a short metal tube, a circular metal vessel to contain the ether. On the other side of this is a thin india-rubber bag, also connected with the ether-chamber by a short tube. The ether-vessel can be rotated on the face-piece, and according to the position in which it is placed, the course of the air passing through the apparatus varies. When it is turned so that the small indicator points to "no ether," the expired air passes into the bag without entering the ether-chamber, and is breathed again at the next inspiration. When at "full ether," the air in inspiration from the bag and expiration into the bag must all pass through the ether-chamber, which is warmed partly by the patient's breath, and partly by the administrator's hand on the outside. By a simple mechanical arrangement these variations in the direction of the air are effected without valves, and the instrument is for this reason less likely to get out of order. It is thus used. First the face-piece is fitted to the patient's face with the ether-chamber, but without the bag, and with the indicator pointing to "no ether." The patient is allowed to breathe through it a few times to get accustomed to it. Then the bag is applied, and he commences to breathe the same air over and over again. This soon produces a slight stupefying effect, and after a few respirations the ether-vessel is rotated so as to gradually allow more and more ether-vapour to be mixed with the air. After a few more respirations the full amount of ether should be turned on. In this apparatus there is purposely no provision for the admission of fresh air, and if it were held firmly to the face for a sufficient time death from asphyxia must ensue. The administrator judges by the appearance of the face when air is needed, and removes the whole apparatus for one or more respirations as he may think necessary. The administration of ether by this apparatus gives rise to less choking than when the vapour is given from a hollow sponge.

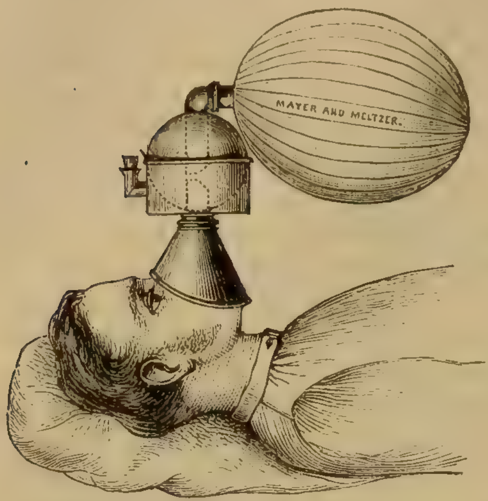


Fig. 1.—Clover's Ether Inhaler.

The effects of ether resemble generally those of chloroform; the patient is brought to the same state of total unconsciousness, with complete muscular relaxation and abolition of all reflex movements, except those concerned in maintaining the action of the heart and respiration. Ether produces, however, more excitement than chloroform, especially if the vapour be considerably diluted with air. It causes also at the commencement a choking sensation, often very distressing. It always gives rise to a copious secretion of mucus both in the pharynx and bronchial tubes, which may cause considerable respiratory embarrassment, the respiration, both abdominal and thoracic, being violent and forcible. Ether exerts a more stimulating effect on the heart than chloroform, the pulse usually maintaining its force even when the patient is deeply under the influence of the anæsthetic. The pupil, as in the administration of chloroform, is variable until the extreme limits of safe adminis-

tration are reached, when it becomes widely dilated and fixed; at this time, also, the face is slightly dusky. The time required for the induction of the anæsthetic state varies, averaging, perhaps, five minutes, if administered without an inhaler, but much less if Clover's apparatus be used. The same precautions as to relaxation of the dress, the recumbent position, and abstinence from food, that have been described as necessary during the administration of chloroform, must be attended to when ether is given. Ether, like chloroform, may give rise to troublesome vomiting both during and after its administration.

Death from the administration of Ether, although not a frequent occurrence, has occurred with sufficient frequency for certain facts to be ascertained with regard to it. Cawtley Dawson, in the *British Medical Journal*, March 2, 1878, has published a collection of eighteen cases in which death occurred either during or soon after the administration of ether. Of these he excludes nine, on the grounds that ether was not the only anæsthetic used, or that it is possible the death may have been due to other causes. In the remaining nine cases, in seven the heart continued to beat for some time after the respiration had ceased, and in two this point was doubtful. All the patients died from asphyxia, as indicated by the dusky face, and shallow respiration, and the long interval, varying from four minutes to fifteen or more, between death and the first manifestation of serious symptoms. At the post-mortem examination the lungs were found gorged with blood in five of the seven cases examined; in one more the pulmonary artery was said to be engorged; in one only were the lungs pale, and in this case the symptoms did not come on till one hour and a half after leaving the theatre. The conclusion to be drawn from these cases is, that ether kills by asphyxia and not by syncope; and this is in accordance with the results of experiments on animals in which ether was found always to kill by arresting the respiration. Ether has therefore the advantage that when it does give rise to dangerous effects, the serious symptoms develope gradually, and there is plenty of time to adopt such measures as may be necessary to restore the patient.

Comparison between Ether and Chloroform.—The history of Anæsthetics furnishes an additional illustration of the mutability of professional opinion. Ether was almost the only anæsthetic employed for the first year after the discovery of its use as an anæsthetic. It then rapidly gave way to chloroform; and so completely was this agent substituted for ether in this country and generally throughout Europe, that a confusion arose in the public mind as to the real discoverer of Anæsthesia; and Sir James Simpson, who was one of the first to employ chloroform and to whose energy its general adoption was mainly due, was very commonly considered to be the discoverer of Anæsthetics. In some hospitals, however, and more especially those of Boston, the birthplace of surgical Anæsthesia, the faith in ether has never been shaken, nor its use abandoned for that of any other agent. In this country a change of professional opinion has to some extent set in, and strenuous efforts have been made since the death of the illustrious discoverer of the anæsthetic properties of chloroform to decry that agent, and to re-introduce ether as a general anæsthetic.

That ether and chloroform are equally effective in the production of Anæsthesia, is undoubted. But the advocates of the first allege that it is the safer agent of the two; whilst those of the latter assert that, admitting the greater

safety of ether, it is equally certain that it is less convenient and less generally applicable as an Anæsthetic.

This question, then, has to be examined from three aspects :—1. As to the applicability ; 2. As to the convenience ; and 3. As to the safety of the two Anæsthetics.

1. *As to Applicability.*—There can be no doubt that in the vast majority of cases both are equally applicable. But there are certain cases in which ether, and others in which chloroform, appears to possess superior advantages.

Ether is preferable in those cases in which from severe shock the nervous powers are greatly depressed, and in those in which there is atony of the heart, whether from fatty degeneration or from an enfeebled and dilated state of the ventricles.

Chloroform appears to be more applicable in all those cases in which it is necessary to maintain the anæsthesia for a great length of time—for many hours—as in the compression of an artery in the treatment of aneurism ; and in those cases in which the galvanic cautery is used in the neighbourhood of the mouth or air-passages, the vapour of ether under these circumstances being liable to ignite with explosive violence, as I have seen happen.

In all abdominal surgery chloroform is preferable, as the violent respiratory movements, that so commonly occur in consequence of the accumulation of mucus in the lungs and larynx during the administration of ether, may prove a most serious inconvenience to the Surgeon. The relaxation of the abdominal muscles is much more perfect with chloroform ; and as this is of the first importance in the treatment of strangulated hernia, whether by taxis or operation, in abdominal sections, and in examination of abdominal tumours, chloroform should always be used in such cases. In young children, also, chloroform is always to be preferred, firstly, because no apparatus is required, it causes less choking and discomfort, is much more easily given, and frightens the patient less ; and secondly, because experience has shown that children take chloroform with remarkable ease and safety.

2. *As to Convenience.*—In this respect, chloroform undoubtedly possesses a vast superiority over ether, and indeed it was its superiority in this respect that led so rapidly to its substitution for that agent. Snow formerly compared the two agents to a lucifer-match and a tinder-box respectively ; and also to an express and a slow train, in which we regard convenience rather than safety.

Chloroform is infinitely more convenient than ether in many ways. By it the anæsthesia is more rapidly induced, and when once induced, it is more easily maintained complete and unbroken. The quantity required to produce anæsthesia is far smaller. This is a most important advantage in midwifery and in military and naval practice, where the larger bulk of the ether that is consumed in inducing anæsthesia would often render its employment very difficult. So also in ordinary country practice, where Surgeons have to work single-handed or with imperfect assistance, the readiness with which anæsthesia is induced by chloroform is a very important consideration in its favour. The penetrating and long-persistent odour of ether, though of minor import, is not without its disadvantage to many who are delicate or susceptible.

3. *As to Safety.*—No anæsthetic is absolutely safe. It is impossible to annihilate, even temporarily, mental consciousness and physical sensibility without some risk. With ordinary care and some degree of experience, this risk is

capable of being reduced to very trifling proportions. So small is the risk, that many a Surgeon goes through a lengthened hospital experience without meeting with a fatal case. But, slight as is the danger from the administration of anæsthetics by competent persons, there is still undoubtedly a certain definite peril attendant on their use. That this is somewhat greater when chloroform is used than when ether is employed is generally acknowledged—how much greater is uncertain. There are no data before the profession from which a comparative estimate of the relative danger of these two agents can be drawn.

That many fatal accidents have occurred from the administration of chloroform during the twenty-five years in which it was almost the exclusive anæsthetic used in this country, is unfortunately too true. In the ten years 1868 to 1877, no less than 138 were recorded in the medical journals of this country alone. How many of these were inevitable—due to causes beyond the control of the administrator and solely referable to the toxic action of the anæsthetic—is uncertain.

That but few fatal accidents have as yet followed the administration of ether is certain. How far this is due to this anæsthetic being actually safer—*i.e.*, less toxic than chloroform—is uncertain; and the comparison is at present scarcely just. For, since the re-introduction of ether into practice, it has chiefly been employed by professed and experienced anæsthetists; and much greater skill in the management of anæsthetics has been acquired by the profession generally than could or did exist in the earlier days of the practice.

The following report places some of the facts respecting the comparative value of chloroform and ether in so clear a light that I have thought well to reproduce it.

Report on the administration of Chloroform and Ether as Anæsthetics.—By Surgeon-Major J. H. PORTER, Assistant Professor of Military Surgery.

During the year 1875 chloroform and ether were administered at Netley Hospital in 21 and 26 cases respectively.

The following is an analysis of the time taken to place the patient under its influence, the quantity used, and their general effects as taken from a Register kept for that purpose:—

CHLOROFORM.

	Minutes.	Seconds.
Shortest time taken to place under influence	2	30
Longest time ,, ,, ,,	14	30
Average time ,, ,, ,,	6	24
Average time under influence	12	48
Smallest quantity used in any one case	1 drachm.	
Largest quantity used ,, ,,	8 ,,	
Average quantity used ,, ,,	3 drachms 9 minims.	

Vomiting occurred in two cases during or after administration of the drug.

Excitement occurred in ten cases during or after administration of the drug.

Great prostration in one case after administration.

ETHER.

	Minutes.	Seconds.
Shortest time taken to place under influence	3	30
Longest time ,, ,, ,,	24	0
Average time ,, ,, ,,	8	10
Average time under influence	19	6
Smallest quantity used in any one case	2 ounces 4 drachms.	
Largest quantity used in any one case	9 ounces.	
Average quantity used in any case	5 ounces 1 drachm.	

Vomiting occurred in eleven cases during or after the administration of the drug.

Excitement occurred in seven cases to a marked degree during or after administration of the drug.

The anæsthetics were invariably given on empty stomachs, chloroform by means of a handkerchief or towel folded into the form of a cone, and ether by Mr. Morgan's inhaler.

Vomiting and excitement during or after administration of ether having occurred more frequently than one had been led to expect from former experience, the anæsthetic was carefully analysed and was found to be perfectly pure, and of specific gravity 720·2 at 64° Fah.

In conclusion, I would say that, with reasonable care and in fairly skilled hands, both chloroform and ether are agents that may safely be administered in the vast majority of cases requiring surgical operations : that in most cases they are equally applicable : that in some chloroform, in others ether, is the preferable agent : that in midwifery, military, naval, and single-handed country practice, chloroform, being far less bulky, more portable, and more easy of administration, is preferable to ether ; but that, so far as we can at present judge, ether less frequently than chloroform produces a direct toxic influence on the heart, and is consequently so far the safer agent of the two.

Nitrous Oxide Gas was the first anæsthetic used. Its employment was, however, soon discontinued, ether, and subsequently chloroform, taking its place. It was, however, re-introduced in 1863 as an anæsthetic by the American dentists. It is an admirable anæsthetic, capable of producing complete insensibility, rapid in its action, safe in administration, and seldom giving rise to any unpleasant after-effects. It has, however, one drawback which prevents its applicability to prolonged operations. The class of cases to which the nitrous oxide is applicable as an anæsthetic is restricted, owing to the shortness of the duration of the anæsthesia produced by it, and the suddenness and completeness of the return to consciousness, leaving the after-smart of the operation almost as severely felt as the sting of the cut itself could have been. Nitrous oxide is chiefly of use in operations unattended by cutting, as in the forcible flexure of stiffened joints, the avulsion of toe-nails, extraction of teeth, &c. ; or in those cutting operations which are completed by a single stroke of the scalpel or bistoury, as the opening of an abscess or the division of a fistula.

In order to produce the desired effect, without causing that violent excitement which gained it the name of "laughing gas," it must be administered pure, without the admixture of air. In order to do this, a proper apparatus, with a closely-fitting face-piece, to cover the mouth and nose, must be used. The gas is supplied for use compressed in iron bottles. The bottle is connected with the face-piece by a tube, in the middle of which is an india-rubber bag,

differently placed in different instruments. The principle of all is, however, that after the face-piece has been firmly applied to the patient's face, the bag is distended with gas, by turning the stop-cock connected with the iron bottle, and the patient, breathing backwards and forwards into the bag, inhales the same gas several times. Some of the gas is necessarily lost by escaping from under the face-piece, and its place is supplied by allowing a fresh stream to flow in from the iron bottle. Nitrous oxide is an irrespirable gas, and as, in this method, no air is mixed with it, the effects produced are, to a great extent, those of asphyxia. It differs, however, from the asphyxia produced by obstruction of the air-passages in this, that the elimination of carbonic acid gas continues to a certain extent, so that, although the blood ceases to receive oxygen it does not become over-charged with carbonic acid, and consequently a few breaths of fresh air remove all traces of the temporary asphyxia. The process of anæsthesia by nitrous oxide is not, however, merely asphyxia and nothing else ; a certain proportion of the gas is absorbed, and exerts an influence resembling that of other anæsthetics on the nervous centres. Experiments on animals have shown that, like ether, it always stops respiration before arresting the action of the heart. In the administration of laughing gas the following symptoms are observed. After a time, varying from a few seconds to half a minute, according to the freedom with which the patient inhales the gas, a slight lividity of the face is noticed, and a choking sensation may be felt. In less than one minute, as a rule, this lividity becomes extremely marked ; the vessels of the face are injected, there are often some twitchings of the eyes and limbs, and the breathing is deeper than natural. At this stage sensation and reflex movements are abolished, and a momentary operation may be performed. Sometimes the patient is conscious that something has been done, although he feels no pain, and his ideas are confused. If the operation be more than momentary, the administration of the gas must be continued a few seconds longer. The face then becomes livid, the eyes protrude, the pupils dilate, and the whole appearance of the patient is horrible in the extreme to an inexperienced bystander. The pulse becomes unsteady, and the respiration slow and stertorous. This is the extreme point to which the administration can be carried ; for, as before stated, the gas is irrespirable, and if administered for a sufficient length of time, must necessarily be fatal. Even when carried to this extreme point, however, a few breaths of fresh air suffice to restore the patient perfectly. Occasionally there is some excitement as recovery takes place, but it soon passes off. Vomiting is extremely rare. During the period of insensibility, and the excitement afterwards the patient is very apt to dream ; and consequently it is extremely unwise for a medical man to administer laughing gas, or in fact any anæsthetic, to a female patient without the presence of a third person, as unfounded charges of criminal assault have been made under these circumstances, very possibly in perfect good faith.

Death from the administration of Nitrous Oxide has occurred only with extreme rarity. In 1877 it proved fatal to a medical man, apparently from over-distension and paralysis of the right side of a fatty heart, consequent on the obstruction to the pulmonary circulation, which always occurs from the partial state of asphyxia which the gas induces. In another case, a patient, in the last stage of phthisis, failed to rally and died less than one hour after the gas was administered. Several other fatal cases have occurred from the gag used by the dentist breaking or slipping and becoming impacted in the

larynx. The only conclusions to be drawn from these cases are, that it is not advisable to give it in cases of extreme phthisis or fatty heart, and that it is wise for the administrator to have by his side the instruments necessary for the operation of laryngotomy or tracheotomy whenever the operation is one involving the use of a gag.

Nitrous Oxide and Ether.—As has already been stated, each of these agents possesses certain disadvantages—the anæsthesia produced by nitrous oxide not being sufficiently persistent to admit of the performance of prolonged operations, that of ether being slow of production and often attended by considerable excitement. By the successive administration of the two anæsthetics, these inconveniences are removed, and the advantages of the two secured. The plan adopted by Clover consists in the rapid induction of anæsthesia by the nitrous oxide, and the maintenance of this insensibility by the use of the vapour of ether. In this way one anæsthetic supplements the other, and the safety of the one is combined with the persistence of the other.

Bichloride of Methylene, originally suggested as an anæsthetic by Richardson, has lately been extensively used, especially at Guy's Hospital and at the Moorfields Ophthalmic Hospital. Its advantages over chloroform are said to be greater rapidity of action, complete and rapid recovery, and the absence of muscular rigidity during administration, and of unpleasant after-symptoms. Over nitrous oxide it has the advantage, that the anæsthesia can be maintained for any length of time. Though said to be safer than chloroform, its use is not perfectly free from danger, more than one fatal case having already occurred ; and if used for operations lasting more than two minutes, it seems quite as liable to cause vomiting. To produce rapid anæsthesia, it is necessary that the vapour be inhaled in as concentrated a state as possible, all unnecessary admission of air being avoided. For this purpose an apparatus has been devised by Rendle, consisting of a leather cylinder, open at one end and shaped so as to fit closely over the mouth and nose, the other end being dome-shaped and perforated so as to admit sufficient air for respiration. In the interior of this cylinder is a loosely-fitting flannel bag, which overlaps the open end and is secured by an elastic band. The administration is performed as follows. One drachm of the bichloride of methylene is sprinkled on the inside of the flannel bag, and the leather cylinder is immediately placed over the face of the patient ; at first it must not fit accurately to the nose and mouth, but, as soon as the patient can bear it, it must be pressed firmly down so as to exclude all air, except such as passes through the bag. By these means anæsthesia sufficient for opening an abscess is usually produced under one minute, passing off as rapidly as it was induced. If the administration be prolonged until the drachm of the bichloride is completely exhausted, the anæsthesia usually lasts about five minutes : the patient on recovering being able to walk away with only a slight feeling of giddiness. If necessary, a second drachm may be used to prolong the effect ; but the after-symptoms then resemble those of chloroform, though in a somewhat minor degree. The signs of danger during administration are lividity of the face, and cessation of the pulse and respiration. If they occur, it is best, according to Bader's advice, to place the patient at once in the recumbent position on the *left* side, with the tongue well pulled forward, when the symptoms will gradually pass off. Richardson has concluded from experi-

ments on animals, that in fatal cases respiration and the heart's action cease at the same time. In hospital practice, where time is of considerable importance, it has been found to be a convenient plan to induce anæsthesia in the first instance by means of bichloride of methylene, and to maintain it afterwards as long as may be necessary by chloroform.

Various other substances possessing anæsthetic properties, such as ethyl-bromide, chlorethylidine, &c., have been tried at various times, but have not shown any advantages over those in common use.

The **Treatment of the Effects arising from an Overdose of Anæsthetics** is conducted on two principles :—1, the establishment of respiration, either natural or artificial, so as to empty the lungs of the vapour contained in the air-cells, and to aid the oxygenation of the blood ; and 2, the stimulation of the heart's action, and the maintenance of the circulation.

The first principle of treatment—that of re-establishing respiration—is most serviceable in the asphyxial form ; the other—that of stimulating the heart—when syncopal symptoms are present. But in all cases they may most advantageously be employed in combination.

The treatment to be adopted on the occurrence of dangerous symptoms, or of apparent death from chloroform, is as follows :—

1. The administration of the vapour must be at once discontinued.

2. The tongue should be seized with the fingers, or with a hook or forceps, and drawn out of the mouth ; and the larynx pushed up so that the glottis may be opened. The tongue must be pulled forcibly forwards—not merely pulled out of the mouth—for the reasons before stated.

3. Fresh air should be admitted to the patient by opening doors and windows, and by preventing bystanders or spectators from crowding round.

4. All constrictions should be removed from the patient's throat and chest, and these parts should be freely exposed.

5. Artificial respiration must *at once* and without delay be set up, whilst these other measures are being carried out. This should be done by the Sylvester method, which is fully described in the chapter on asphyxia.

6. Electricity, in the form of faradisation of the phrenic nerve, has been of great use in some cases as an adjunct to artificial respiration. It must be applied methodically as described under the treatment of asphyxia.

7. As accessory means, friction of the extremities may be employed ; a little brandy rubbed inside the mouth ; and cold water dashed on the face.

The nitrite of amyl would appear, from the experiments of Dabney on animals, and from recent observations on man, to be an antidote to chloroform-poisoning, both in its syncopal and asphyxial forms ; the inspiration of the vapour of ten to fifteen drops of the nitrite unloading the vessels and restoring the heart's action.

8. Tracheotomy or laryngotomy can be necessary only when the asphyxia is due to the impaction of some foreign body, as false teeth or a gag, in the larynx during insensibility, or to accumulation of blood in the pharynx or trachea.

Local Anæsthesia may be induced by freezing a part. This is done in two ways : 1, by the application of a freezing mixture ; 2, by the rapid

evaporation of very pure ether. The application of a frigorific mixture of ice and snow, as introduced by J. Arnott, may very conveniently be employed in many cases in which the internal administration of anæsthetics is either inadmissible or inconvenient. It can be produced with certainty, however, only in those cases in which the incisions implicate merely the skin and subcutaneous structures, as in opening abscesses, slitting up sinuses, avulsion of toe-nails, or removing small and superficial tumours. For all such purposes, however, it is extremely valuable.

The mode of using the *frigorific mixture* is as follows. About a tumblerful of rough ice is put into a strong canvas bag, and finely powdered with a mallet. It is then poured out on a sheet of paper, and half its bulk of salt is quickly mixed with it by means of an ivory or wooden paper-knife. The mixture is then put into a muslin or gauze bag, suspended from a wooden ring, and applied to the part for from five to ten minutes. So soon as the skin becomes white, opaque, and hard, anæsthesia is produced, and the incisions may be made without any pain being experienced. The frozen part speedily recovers, no inconvenience resulting.

The *rapid evaporation of highly rectified ether* has been very ingeniously and successfully applied by Richardson in the production of cold sufficient to freeze a part, and thus render it temporarily insensible. A fine spray-jet of ether of a low specific gravity is thrown upon the part to be anæsthetised. The skin rapidly becomes white and hard—is, in fact, frozen. This method of inducing local insensibility to pain is more exact and efficacious than that by the frigorific mixture, and is generally preferred. It is applicable in the same class of cases. The ether should be tested before it is used by pouring a little into the hollow of the hand, where, if it is of the proper quality, it will boil violently.

PERFORMANCE OF AN OPERATION.

In the performance of an operation in private practice the Surgeon must see for himself that the preparations are properly made. The room must be light, of sufficient size and properly warmed. The table upon which the patient is placed must be of the ordinary height. The strong deal table usually found in kitchens answers the purpose fairly well. It must be very steady on its legs, and if it is not more than three feet wide it will be more convenient. It must be covered with a blanket folded into four layers; another blanket must be provided to place over the patient's body, and pillows must be comfortably arranged for the head. A tray filled with sawdust, or an old blanket folded very thickly may be placed on the floor to catch the blood. The friends must be asked to provide in the room, a dozen towels, four washing basins, and two large cans, one of hot and one of cold water, and a slop-pail or foot-bath. A gallon or more of carbolic acid lotion of the strength of 1 to 20 should be in readiness, which may be diluted to 1 in 40, for washing the sponges. The necessary amount of carbolic lotion, according to the extent and nature of the operation, must first be prepared, and the cans of common water must then be carefully removed to one corner of the room, and orders given to the nurse not to touch them; for, unless she is thoroughly experienced, she is almost certain to use plain water instead of carbolic lotion during the excitement of the operation.

The sponges should be brought by the surgeon himself, and should be properly prepared. Improperly cleaned sponges have always been justly considered a potent source of infection in wounds. New sponges are apt to be gritty from sand, and require very careful washing; after which they should be soaked for at least twenty-four hours in a 1 in 20 solution of carbolic acid before being used. After an operation the meshes of a sponge are more or less filled with coagulated blood, which mere washing in water will hardly remove. In order to clean it thoroughly, it may be soaked in a strong solution of sulphurous acid; or, after maceration for forty-eight hours in a dilute solution of hydrochloric acid (about ten drops of the strong acid to the ounce of water), and for twenty-four hours in a strong solution of carbonate of soda, it may be well washed in common water, and kept ready for use in a bath of 1 in 20 carbolic acid lotion. Another plan is to put the sponge in a basin of common water till the fibrin in its meshes is decomposed and offensive; then wash it well in hot water, or boil it; after which it may be thoroughly washed again, and finally put into a bath of 1 in 20 carbolic lotion till it is wanted.

Before commencing an operation, the Surgeon must look over his instruments, comparing them, if the operation be complicated, with a list previously made out; he must see that they are arranged in the order in which they are wanted, and properly covered with a towel. Much of the successful performance of an operation depends on the attention and steadiness of the assistants. Of these there should be enough, but not too many. In all capital operations three or four will be required; one for the administration of the anæsthetic, another to command the artery, a third immediately to assist the Surgeon, and the fourth to hand sponges, instruments, &c. The duties of the assistants should be performed in silence, and each man must carefully attend to his own business, and not neglect this, as is too often done, in his anxiety to crane over and see what the Surgeon is about. There should be no unnecessary talking when once the patient is on the table; the Surgeon's directions ought to be conveyed by a brief word or two, by a look, or by a sign with the hand.

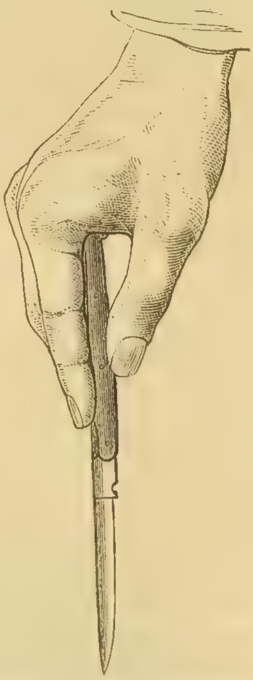


Fig. 2.—Bistoury held perpendicularly.

The incisions for the operation should be carefully and properly planned, so as to give sufficient space with as little mutilation as possible; but it must always be borne in mind, that although a needlessly long incision may lead to unnecessary disfigurement, it does not add materially to the danger of the patient, while too small an incision hampers the surgeon and greatly increases his difficulties, especially in the arrest of hæmorrhage.

Incisions may be made by cutting from without inwards, or from within outwards, or subcutaneously. The most convenient instrument for all ordinary incisions is the scalpel. This should be set in a smooth ebony handle, which is less slippery than an ivory one when wetted with blood, and admits greater delicacy of touch; it should be light in the blade, nearly straight-backed, and slightly bellied on the cutting edge. The heel should be as wide

as the widest part of the blade, and there should be no constriction where it joins the handle. When very free and extensive incisions are required, as in the removal of large tumours, &c., a Liston's spring-backed bistoury, of proper size and shape, is a very convenient instrument (Fig. 2). For a subcutaneous incision, a very small narrow-bladed knife is required.

The ordinary scalpel is held in two ways: first, like a pen (Fig. 3); secondly, like a dinner-knife (Fig. 4). The former position is that universally adopted in dissecting the dead body, and the habit of always holding the knife in this

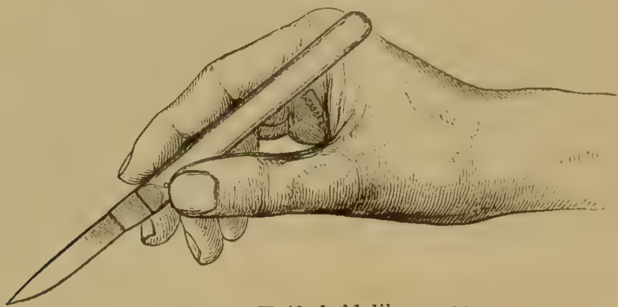


Fig. 3.—Knife held like a pen.

way is one of the first faults which a student commencing operative surgery has to correct. In dissection, also, the student habitually turns his knife from the deep parts towards the skin, so that any slip of the knife may not injure the subcutaneous structures which it is his object to preserve. In raising flaps in the living body, the reverse must be the rule, as, if the skin and subcutaneous tissues are scored by the knife, the flap will certainly slough. No one who has

Fig. 4.—Scalpel held like a dinner-knife.

not taught operative surgery could conceive how difficult it is to correct this most dangerous habit in young operators. In making an ordinary incision from without inwards, as in the removal of a tumour, or in cutting down upon an artery in its continuity, the skin must be put gently on the stretch, and the knife entered perpendicularly to its surface, so as fairly to penetrate the subcutaneous fat; the handle may then be lowered, so that the incision is continued with the belly of the knife. This may be done by drawing the knife steadily along, if the edge is good and the tissues are not particularly resisting; more often, however, a slight rapid sawing movement is required. In bringing the knife out again, the handle should be raised so that there may be no "tailing," but that the incision may be as nearly as possible of equal depth throughout. The bad habit of gradually losing length as the incision is deepened, so that, for example, a four-inch incision through the skin is reduced to three at the fascia,

should be carefully avoided. An ordinary wound is gradually deepened by simply drawing the knife along it, with its edge directed downwards and parallel to the incision, until the deep fascia is reached. As the wound is deepened it is, if necessary, held open by an assistant with blunt hooks or spatulæ. The division of the deep fascia often requires care, as important structures may lie beneath, which it is necessary to avoid. It is done therefore in one of two ways. It may be picked up with a pair of dissecting forceps, and a small hole carefully made in it, through which a director may be inserted, upon which it may be divided, the back of the knife being turned downwards (Fig. 5); or, the small hole having been made in it, the point of one blade of the forceps may be introduced, and the fascia seized and raised slightly from the parts beneath. The side of the knife then being turned downwards, the portion of

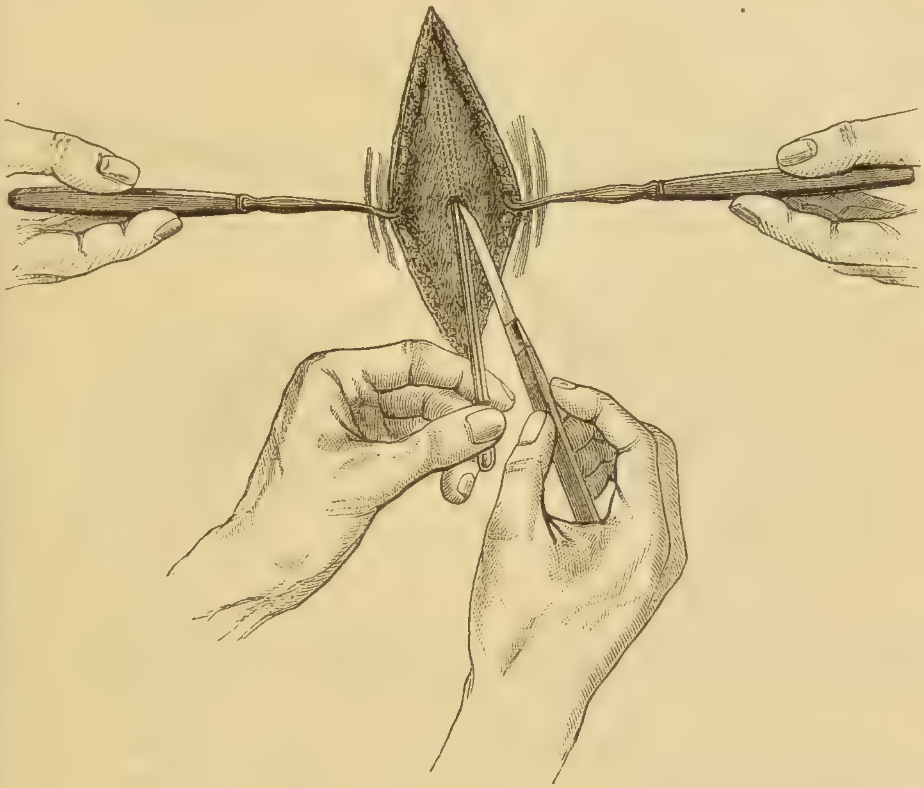


Fig. 5.—Division of the fascia on a director. Blunt hooks holding open the wound.

fascia raised in the forceps is divided in the direction of the incision in the skin, only the last half-inch of the knife being used. A fresh hold is then taken with the forceps, and another piece of the fascia divided in the same way (Fig. 6). With a little practice it is easy in this way to make a clean linear incision through the fascia. It is a much safer plan than that of using a director, as nothing is divided but that which is raised by the forceps, whereas in pushing a director blindly under a fascia its point may pass beneath something which it is not intended to cut. Where the tissues are very lax beneath the fascia, it is often a convenient plan to guide a probe-pointed bistoury on the forefinger of the left hand, instead of using a director. The finger is the best possible director when it can be used, as it can be guided more or less by sensation. Occasionally in deepening a wound through

very loose structures, amongst which important vessels may lie, as in removing tumours from the root of the neck or the axilla, the surgeon may prefer to make use of a blunt instrument, and to tear the tissues instead of cutting them. With this view he may use two pair of forceps, or one pair of forceps and a director, or the handle of the scalpel. He must not, however, be tempted to use these forcibly or rashly, as by so doing much mischief may be produced. He must work methodically, picking up what he intends to tear with the forceps, and being careful to tear only what he has thus seized. In

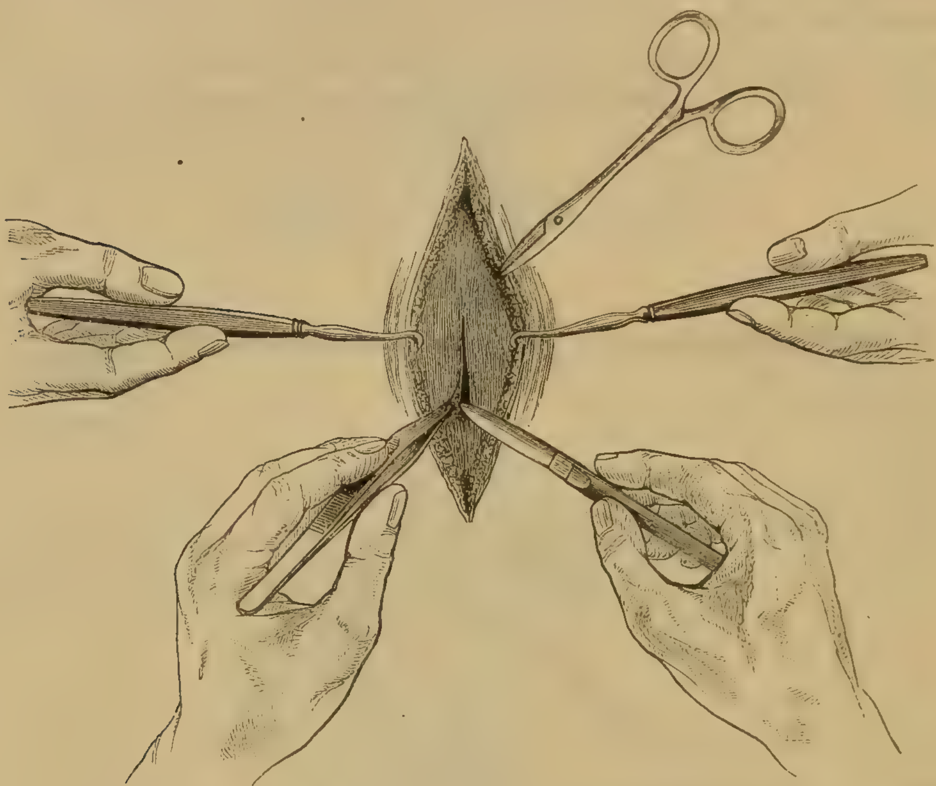


Fig. 6.—Dissection through a fascia. Spencer Wells' forceps on a bleeding vessel. Blunt hooks holding open the superficial wound.

some cases a properly cultivated finger-nail or thumb-nail will be found a most useful instrument.

PREVENTION OF HÆMORRHAGE DURING OPERATIONS.

In every operation involving the use of the knife, loss of blood during its performance is the great primary danger to be guarded against. This may be prevented most conveniently in the extremities by the use of the tourniquet or the elastic band, or by an assistant compressing the main artery of the limb. If the seat of the operation be such as not to admit of this, the assistant may compress the bleeding vessels as they are divided during the operation; and as soon as it is concluded, he can remove his fingers from them, one by one, to admit of their being ligatured or twisted. This plan has, however, the inconvenience of occupying the assistant's hands at a time when they may be wanted to help the Surgeon, and it will be found more convenient if the vessels be seized in a pair of catch forceps of the pattern recommended by Péan & Sir T. Spencer

Wells (Fig. 6). These forceps have scissor handles, and the grasping extremity is roughened by rather deeply cut transverse teeth. They can be applied instantaneously, and their hold is extremely firm, and from their length and weight it is easy for the assistant to keep them out of the wound during the operation, while at the same time his fingers are free to help the operator. At the conclusion of the operation, it will frequently be found that their pressure has succeeded in permanently arresting the bleeding from the vessels to which they have been applied. Their action in this respect will be more fully described in the Chapter on the Permanent Arrest of Hæmorrhage. As a means of temporarily arresting bleeding during an operation, they have proved of the greatest possible value, especially in operations about the head and neck, and abdomen.

The Tourniquet and its Application.—The older Surgeons from the time of Archigenes, a Roman who lived in the second century, bound a tight narrow band, called "the fillet," round a limb during an amputation. The fillet was intended to serve three purposes—first, to steady the muscles during the incision; secondly, to numb the limb; and thirdly, to arrest the flow of blood; but it seems to have but imperfectly succeeded in producing the desired results. In 1674, Morel, a French Surgeon, perfected the fillet by introducing a piece of stick beneath the band, by means of which it could be twisted up and efficiently tightened. To protect the limb from being bruised, he introduced compresses beneath the band; and to ensure the more complete compression of the main artery, he placed a rolled bandage along its course. Beneath the knot, to save the skin from being pinched, he placed a piece of leather or thick paper. To this apparatus, he gave the name of "tourniquet." The tourniquet in this primitive form is still useful, in the absence of any other appliance, for the temporary arrest of hæmorrhage. A round pebble or any hard body about the size of a hen's egg, may be rolled in the middle of a pocket-handkerchief and laid over the artery, the ends of the handkerchief being knotted round the limb, and then twisted up tightly with a piece of stick. In the hands of an ignorant person, however, the pebble would perhaps be better left out, as if it were not applied in the proper place, it might serve merely to relieve the main artery from pressure. The piece of folded paper beneath the knot should never be omitted, or the agony caused by the pinching of the skin would be more than the patient could bear.

The screw tourniquet which replaced Morel's imperfect apparatus, was invented by the great French Surgeon Petit in 1718; and, although the details of its mechanism have undergone improvements, the instrument used in the present day is essentially the same (Fig. 18). It may be applied with or without a pad over the artery. If a pad be used, it is best made of a common roller, from two and a half to three inches wide; of this a few feet must be unrolled. The roller is then placed longitudinally on the artery, and the unrolled part carried twice round the limb so as to keep the pad in position, but care must be taken in doing this not to constrict the part sufficiently to cause venous engorgement. The tourniquet is then applied, and the band buckled with sufficient tightness to keep it in its place; but the instrument should not be screwed up until the moment of the operation. It should then be tightened rapidly, so as to lessen the liability to congestion of the lower part of the limb that always occurs when a tourniquet is applied, but which is especially apt to ensue when the instrument is slowly screwed up. The first effect

of the tightening of the tourniquet is to compress the large veins of the limb; the second, to arrest the flow of blood through the arteries: hence the more slowly it is caused to act, the greater will be the venous engorgement of the limb. The blood that flows from the limb during an amputation when the tourniquet is applied as above described, is almost entirely venous, coming from the lower part of the member.

A screw tourniquet may be equally well applied without a pad (Fig. 11); but it is then necessary to put a piece of card, folded paper, or leather, beneath the screw to save the skin from being pinched. The pad has the disadvantage of being liable to slip, and if not very accurately applied, it tends rather to protect the artery from pressure than to compress it efficiently. The screw tourniquet is now almost completely abandoned in favour of the simple elastic band. It is, however, a useful instrument when the Surgeon is short of skilled assistants, and especially in such cases as wounds of large arteries, in which an occasional relaxation of the tourniquet is required to guide the operator to the injured vessel.

Compression by Elastic Tubing or Bandage.—The circulation through a limb may be completely arrested by two or three turns of an elastic bandage applied with moderate firmness. The bandage may then be secured by a knot or by a pin. During the Franco-German War, the field tourniquet served out to the German army, consisted of nothing more than a narrow elastic bandage about one inch in width, and three feet long. Esmarch, of Kiel, introduced as a substitute for the bandage, a piece of india-rubber tubing about three-quarters inch in diameter, and 2 feet in length, having a hook fixed to one end and an eye to the other. This is stretched and wound firmly and rapidly round the limb two or three times. It often happens that the hook does not meet the eye exactly as it is wanted to, so that either an extra turn of the tube must be put round the limb, or the former turns must be unduly relaxed. This may be obviated by replacing the hook and eye by two pieces of stout tape, bound on to the ends of the india-rubber tube. The tube can then be applied with exactly the amount of force required, and secured by tying the ends of the tape together. It must be remembered that in applying the band, enormous pressure is easily obtained by a few turns one over the other, so much so, that in situations in which the chief nerves lie very close to the bones, as in the arm, symptoms of paralysis, sometimes lasting for weeks, are recorded by Langenbeck as having resulted from its use. Such accidents are more likely to occur if the narrow tube is used, than if the constriction be made by a bandage. The latter should therefore be preferred where it can be conveniently applied.

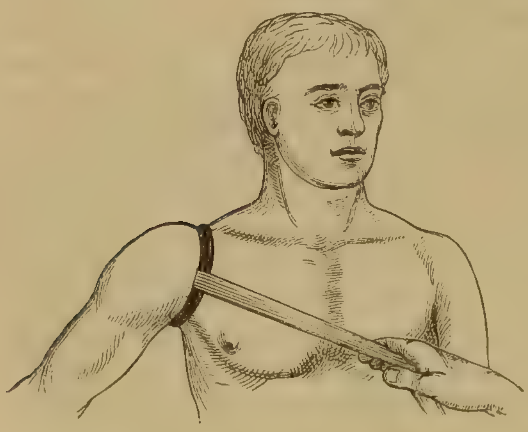


Fig. 7.—Esmarch's Tourniquet applied to Shoulder.

In certain regions special plans have to be adopted in the application of the elastic tourniquet.

In excisions or amputations of the **shoulder**, the india-rubber tube must be

very forcibly stretched and applied round the shoulder, the lower part of the turn being high in the axilla, so as to compress the artery against the neck of the scapula and the upper part, as far as possible, internal to the end of the clavicle, and the acromion process. To prevent its slipping inwards, a piece of bandage should be put beneath it both in front and behind at the time it is applied, by means of which an assistant may hold it in position (Fig. 7).

In operating upon the **upper part of the thigh**, the india-rubber tube must be of sufficient length to go round the limb and the pelvis. The middle of the tube is to be applied to the front of the thigh immediately below the groin; the two ends are then to be carried forcibly round and brought up to the front again, where they cross and are afterwards passed round the pelvis immediately below the crest of the ilium.

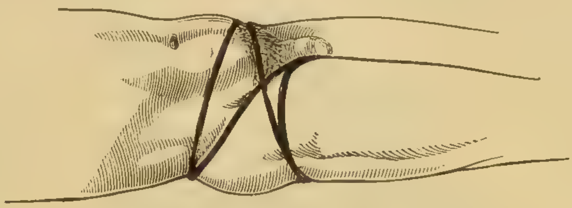


Fig. 8.—Esmarch's Tourniquet to Thigh.

In amputation at the **hip-joint**, a long piece of bandage must be laid upon the middle of the groin in the line of the limb, and a similar piece behind, over which the tube is to be applied, so that by pulling on the ends of the bandage any slipping of the band may be prevented during the operation. The middle of the tube is to be placed in the perinæum, and the ends pulled forcibly outwards and crossed as high above the trochanter as possible, and afterwards carried round the pelvis immediately below the crest of the ilium (Fig. 9). If the bandage is applied with sufficient force, it is quite unnecessary to put any pad over the artery. In the accompanying figure the patient is lying on his side with the right thigh flexed, in the position for an oval amputation at the hip joint.

In operations upon the **penis or scrotum**, a piece of bandage should be laid along the spine behind and brought forward to the scrotum in front. The middle of the tube is then placed in the perinæum, and the lower end of the bandage turned up over it. The ends of the tube are then brought forwards forcibly, and crossed on the pubes, and afterwards carried round the pelvis mid-way between the trochanters and the crest of the ilium, passing between the two

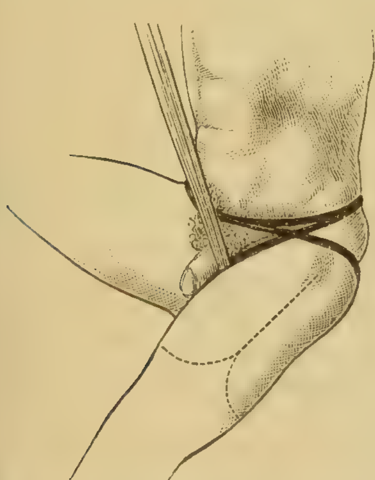


Fig. 9.—Arrest of Hæmorrhage. Operations on the Hip Joint. The dotted line is the incision for the oval amputation at the hip joint.

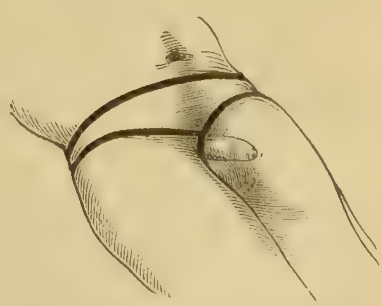


Fig. 10.—Esmarch's Band applied for Operations on the Penis or Scrotum.

parts of the bandage, which are then tied together, thus attaching the loop of the tube that surrounds the scrotum to the part which passes behind; any slipping of the tube during the operation is thus rendered impossible (Fig. 10).

Bloodless Methods. — Various devices have been employed for many years past to diminish the loss of blood during operations on the extremities, and at the same time to get rid of the blood which otherwise fills the wound, and more or less conceals the steps of the operation, even when the tourniquet had been applied. The oldest of those is bandaging the limb firmly to the level at which the tourniquet is applied, before tightening the screw. This was found not to be very efficient, especially when a pad was used over the main artery beneath the band of the tourniquet. Lister has shown that the limb may be rendered absolutely bloodless by simply elevating it as high as possible for about one minute, and then rapidly applying an elastic band or a screw tourniquet without a pad. To hasten the emptying of the blood-vessels the limb may be rubbed firmly in the direction of the circulation (Fig. 11). By experiment he has further shown that this is brought about not only by the emptying of the veins, but by contraction of the arteries which occurs when the limb is placed in the elevated position. Esmarch of Kiel has attained the same result by applying an elastic bandage spirally from the distal extremity of the limb upwards to the point at which the tourniquet or elastic band is applied (Fig. 12). On removing the elastic bandage from below the tourniquet, the limb will be found to be absolutely bloodless, even the bones very frequently yielding no blood on being cut. With the exception of the elasticity of the skin and the retraction of the muscles, the operation exactly resembles one on a dead body. In this state, all vessels of any size can be seen and tied before the tourniquet is removed. On removing the tourniquet, when the blood returns to the wounded part, very free oozing will set in, which often takes some time to arrest by means of cold and exposure to the air. Thus it may happen that the patient loses as much blood as if Esmarch's method had not been employed.

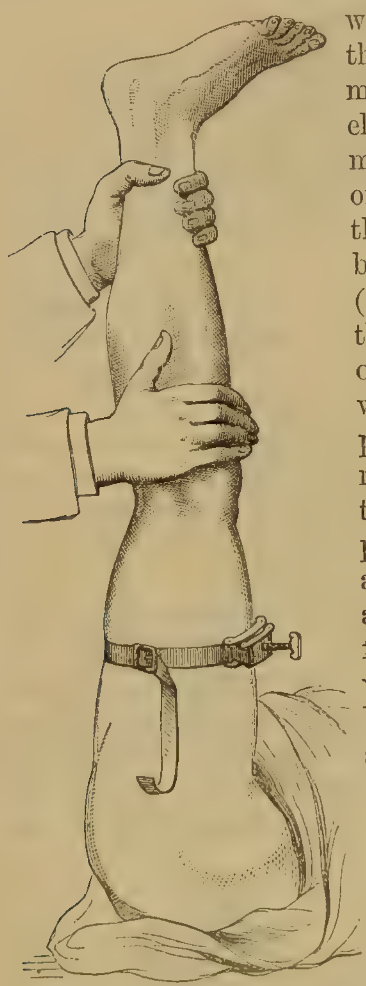


Fig. 11.—Lister's Method.

Esmarch has, however, lately adopted a plan by which he asserts that most operations on the extremities can be rendered actually bloodless. He first secures every vessel visible on the surface of the wound, and then, having put in the drainage tubes and introduced the sutures, he applies a dressing composed of antiseptic gauze surrounded by cotton wool impregnated with salicylic acid, which is moderately firmly bandaged to the part. The limb is then placed in an elevated position, and finally the elastic tourniquet is removed. The elevated position is maintained for at least a half hour or an hour. In 12

cases of amputation and 56 excisions in which this plan was tried, it succeeded perfectly. In 148 operations for necrosis, it was necessary to remove the dressing on account of hæmorrhage in six cases only.

Various objections besides the subsequent oozing have been raised to Esmarch's bloodless method. It has been stated that it causes sloughing of the flaps and increases the tendency to secondary hæmorrhage after large amputations, by unnaturally augmenting the proportion of blood in the body, and so giving rise to increased arterial tension. Neither of these statements is supported by experience. A more rational objection against it is, that when the limb is infiltrated with the products of inflammation, or when perhaps clots exist in the veins, these may be driven on into the circulation by the application of the elastic bandage. Although no case of such an accident has

Fig. 12.—Esmarch's Method.

been recorded, it would be safer when such conditions exist to empty the limb of blood by the simpler plan of elevation as before described. The same plan is also better employed in cases of cancer or sarcoma, in which the danger of dislodging particles and driving them into the circulation would be very considerable.

The advantages of the bloodless method of operating, especially in diseases of bones and joints, far outweigh any supposed disadvantages.

It is difficult to say how long complete arrest of the circulation through a limb may be maintained by the elastic band or the tourniquet without danger of gangrene. It must necessarily vary according to age. Esmarch's method has been used for about three hours without any evil result.

Compression of the Main Arterial Trunk is in the present day employed only as a temporary expedient before a tourniquet can be applied, or immediately after its removal, while a few vessels before invisible are being secured, or in those situations in which the application of a tourniquet is impossible. It is far safer to trust to an instrument, than to the hands of an assistant, however steady and strong. When the tourniquet is applied with a sufficient degree of tightness, the whole circulation through the limb is completely arrested. This can never be done by the compression of the main trunk alone, the collateral vessels conveying blood into the limb independently of it. Then again, if the operation be unexpectedly protracted from any cause, the fingers of an assistant may tire or stiffen ; and, the steadiness of their pressure becoming relaxed, hæmorrhage may ensue. For these reasons, Surgeons invariably employ the tourniquet in amputations ; and even Liston, who at one period of his career discarded this instrument, commonly employed it during the latter years of his life.

The points chosen for the compression of arteries are those at which the

vessel is comparatively superficial, and is placed over some bone against which it can be pressed. The following are the chief arteries which the Surgeon may be called upon to compress.

The **Common Carotid** can be felt pulsating just internal to the sterno-mastoid, and is best compressed by pressing the thumb directly backwards towards the vertebræ opposite the cricoid cartilage (Fig. 13). To steady the hand, the fingers should grasp the back of the neck. It must not be forgotten that if the pressure be applied below the transverse process of the sixth cervical vertebra, the vertebral artery will be compressed at the same time as the carotid.

The **facial artery** is easily compressed against the jaw, where it lies quite superficially immediately in front of the anterior border of the masseter. The

Fig. 13.—Compression of the Carotid

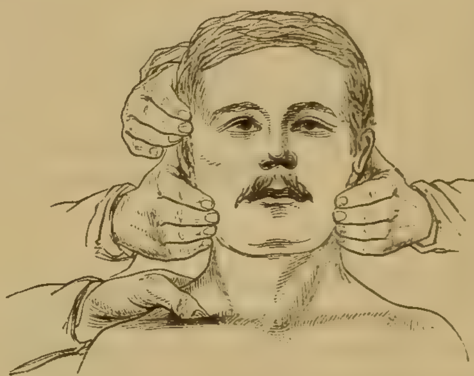


Fig. 14.—Compression of both the Facial, right Temporal, and right Subclavian Arteries.

fingers may be placed on the opposite side of the jaw to steady the hand, and if necessary, the fore-finger may compress the opposite artery. In operations upon the nose and lips the assistant may stand behind the patient and compress both vessels while he holds the head as in the figure (Fig. 14).

The **temporal artery** is compressed where it can be felt pulsating immediately in front of the ear (Fig. 14).

The **subclavian artery** may require compression in the third part of its course in operations in the axilla, or on the shoulder joint, or in amputations high up in the arm. If digital compression be attempted the fingers should be placed behind the lower part of the neck, with the palm of the hand on the ridge formed by the trapezius. The thumb is then forcibly pressed upon the artery, where it lies on the first rib, immediately external to the outer border of the sterno-mastoid and opposite the most prominent part of the clavicle (Fig. 14). A considerable force is required efficiently to compress this artery, the fingers of the opposite hand may be pressed upon the thumb which is upon the vessel. The patient's head should, if possible, be inclined towards the side on which the artery is being compressed, so as to relax the cervical fascia. As the force required is often so great that the assistant is apt to become fatigued and relax his pressure, it is often better to compress the artery with some mechanical contrivance. That most commonly employed is a large door-key. The ring of the key is wrapped round with a strip of lint, so as to pad it sufficiently to

prevent it injuring the patient; the other end is also well padded to protect the surgeon's hand. The padded ring is then pressed forcibly down upon the artery in the situation before described (Fig. 15).

Fig. 15.—Compression of Subclavian, with key, and Digital Compression of the Brachial.

In cases in which the clavicle is pushed up by an aneurismal tumour, Syme recommended that an incision should be made above the clavicle through the skin and deep fascia, so that the fingers of the assistant might be brought to bear almost directly upon the vessel, which would thus be securely and effectually compressed.

The **brachial artery** is best compressed by grasping the limb opposite the middle of the arm in such a way that the tips of the fingers are placed immediately internal to the edge of the biceps, and thus press the artery against the bone while the thumb rests against the humerus on the opposite side (Fig. 15).

The **radial and ulnar arteries** frequently require compression while the surgeon is searching for a wounded vessel in the palm of the hand; and the assistant must, under these circumstances, steady the hand as well as compress the vessels. He will best effect these objects by grasping the lower part of the fore-arm firmly with both hands, his fingers being at the dorsal aspect, and his thumbs pressed upon the arteries immediately above the wrist; on the radial, at the point at which it is commonly felt, as the pulse, and on the ulnar, at the outer border of the tendon of the flexor carpi ulnaris (Fig. 16).

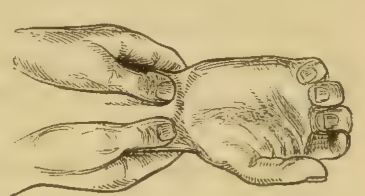


Fig. 16.—Compression of the Radial and Ulnar Arteries.

Compression of the abdominal aorta is required in some cases of amputation at the hip-joint or high up in the thigh, and in operations for aneurism of the iliac arteries, or the branches of the internal iliac in the buttock. The point at which it is most conveniently compressed is immediately above its bifurcation. The bifurcation of the aorta takes place on the body of the fourth lumbar vertebra, a little to the left of the middle line; superficially this corresponds to a point a little to the left side of the umbilicus, and on a level with the highest part of the iliac crest. In compressing the aorta, therefore, the pressure should be applied a little above and to the left of the umbilicus. In children, and very thin subjects, the aorta can readily be compressed with the hand in this situation, but the force required is so great that it is impossible for it to be maintained for any length of time. In the absence of any other instrument, Esmarch recommends the following plan:—A common roller bandage about two and half inches wide and eight yards long is to be rolled round a stick about the thickness of the thumb and nine inches long. The pad thus formed is held in the proper position by the ends of the stick, while

several turns of elastic bandage are passed round the body so as to press it forcibly against the spine. After it is applied an assistant must continue to hold the pad in position by means of the stick. An objection common to this and to all other elastic appliances for compression of the aorta is, that should the patient vomit, the forcible contraction of the abdominal muscles will almost certainly lift the pad from the aorta and relax the compression. It is better, therefore, whenever possible, to use the instrument known as Pancoast's or Lister's Aortic Tourniquet (Fig. 17). This consists merely of a large horse-shoe clamp, one end of which is expanded and padded so as to fit the spine, and the other receives a screw which presses down a pad of sufficient size to compress the aorta with certainty. Lister states, that from examination of a considerable number of bodies, he has found that the aorta is as often in the middle line as to the left of the spine, and consequently it is better always to feel for the pulsation before applying the pad, taking the highest point of the crest of the ilium as the level of the bifurcation, and ignoring the umbilicus altogether. If the pad be placed exactly on the vessel, a comparatively slight amount of force is required to arrest the flow of blood, but should it be misplaced the Surgeon may be tempted to use an amount of force which might prove injurious to the soft parts and intestines beneath the pad. In order still further to avoid injury to these parts, it is well to place a soft hollow sponge beneath the pad. The instrument, when properly applied, interferes but slightly, if at all, with the flow of blood through the vena cava.

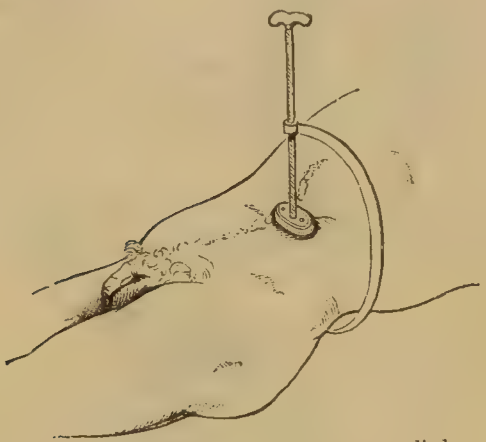


Fig. 17.—Lister's Aorta Compressor applied.

Compression of the common iliac may easily be carried out by the application of the aortic tourniquet over the line of the artery, that is to say in the upper third of a line drawn from a little to the left of the umbilicus at the level of the highest point of the crest of the ilium to a point midway between the symphysis pubis and the anterior superior iliac spine. Richard Davy, of the Westminster Hospital, has invented a plan of compressing this artery by means of a straight lever of wood introduced per rectum, which usually answers very well. The lever should be about two feet in length, smooth and round, and shaped something like a poker. About two ounces of olive oil having been injected into the rectum, the end of the lever is introduced to such a distance that its point comes to lie over the artery in the groove between the last lumbar vertebra and the psoas muscle. By raising the handle of the lever and bringing it against the opposite thigh, the artery is most efficiently compressed, the tissues of the perinæum acting as the fulcrum.

Compression of the external iliac can be carried out with certainty only immediately above the groin, as above that point it is easily pushed over the brim of the pelvis into such a position as to escape pressure. If it be desired to compress it, it may readily be done either with the fingers or by placing a roller bandage across the line of the artery, and securing it first by a few turns

of a common bandage, passing in a figure of eight round the upper part of the thigh and the pelvis below the crest of the ilium, over which must be put a few turns of an india-rubber bandage.

Compression of the femoral artery at the brim of the pelvis (Fig. 18) is commonly resorted to for the temporary arrest of hæmorrhage from any part of the lower limb. It is thus performed. The Surgeon stands by that

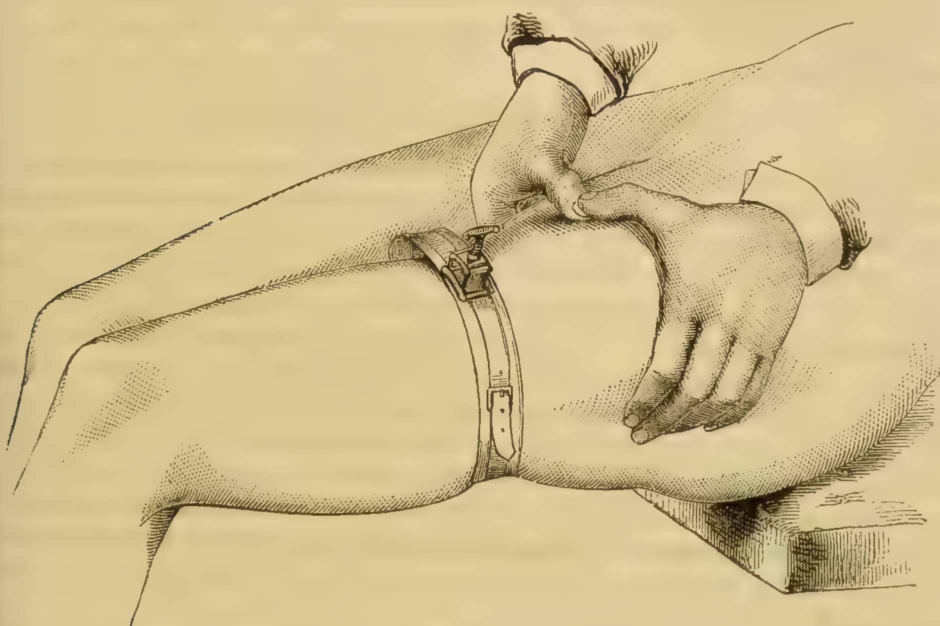


Fig. 18.—Pressure with Thumbs. Application of Tourniquet to Femoral Artery.

side of the patient on which the vessel is to be compressed, with his back towards the patient's head and his body inclined over the pelvis. He then grasps the limb firmly with both hands, the fingers of one hand obtaining a hold on the mass of the adductor muscles, and those of the other on the posterior border of the trochanter major. His two thumbs are placed, one over the other, upon the artery at a point immediately below Poupart's ligament, and exactly midway between the symphysis pubis and the anterior superior iliac spine—where the vessel lies over the hip-bone. Instrumental compression in this situation is employed only in the treatment of aneurism, and will be described with that disease.

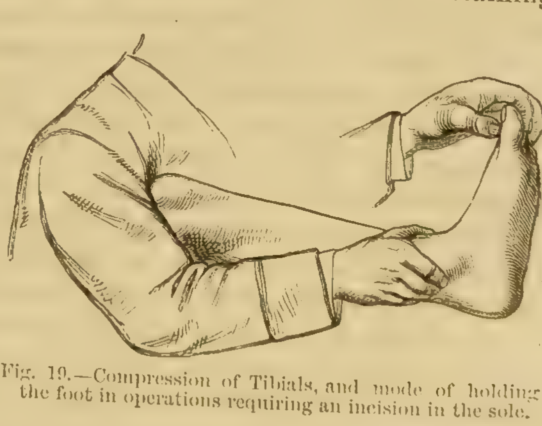


Fig. 19.—Compression of Tibials, and mode of holding the foot in operations requiring an incision in the sole.

The popliteal artery is too deeply situated to be compressed with advantage. In bleeding from a point below the knee and above the ankle, it is better to apply the pressure to the femoral artery at the groin.

The anterior and posterior tibial arteries at the ankle may conveniently be compressed during an operation on the foot (Fig. 19). The

assistant may, at the same time, steady the foot, and hold it in a convenient position for the Surgeon. The limb being bent at a right angle, the assistant puts the patient's knee in his axilla; he then grasps the limb firmly with one hand above the ankle, and with the finger and thumb compresses the vessels. The posterior tibial is to be compressed with the tips of the fingers one finger's breadth behind the internal malleolus, and the anterior tibial with the thumb in front of the ankle at a point exactly midway between the two malleoli, that is to say, a little to the outer side of the middle line.

CONSTITUTIONAL EFFECTS OF OPERATIONS.

Every operation of any importance is followed by a certain amount of *traumatic fever*, as indicated by a rise of temperature, an increased frequency of the pulse, and some degree of thirst. Such fever, if moderate and confined within certain limits, can scarcely be looked upon as a morbid condition; and unless it is kept up by some unhealthy state of the wound, by the presence of decomposing matter, or by pent-up discharges, it completely subsides by the third day. The thermometer is the only certain means of judging of the degree of fever. The pulse is a fallacious sign, being greatly influenced by the mental state of the patient and many other causes; thirst also may be occasioned by the anæsthetic; but the temperature is an infallible guide. If the thermometer remain below 100° F. no anxiety need be felt on this score.

The **Local Treatment of Operation-Wounds** differs in no respect from that of accidental wounds, and will be treated of in the Chapter on the treatment of such injuries.

The **Constitutional After-treatment** of operations demands as much attention on the part of the Surgeon as the management of the wound itself. Immediately after the operation, and before the effects of the anæsthetic have passed off, the patient should be comfortably arranged in bed, with the clothes supported by a cradle, or other contrivance, away from the part implicated; an opiate may then be administered if required, or a little wine and water if there be faintness, and the patient kept as quiet as possible.

With regard to the **Diet after the operation,** this must depend entirely on the patient's constitutional powers, his previous habits, his age, and upon the severity of the operation. But, as a general rule, it may be stated that, as an operation is a shock to the system, the constitutional powers require to be maintained after its performance. This is more particularly the case, if the mutilation be severe, or the subsequent suppuration abundant. If the patient's strength be good, not having been broken by previous disease or suffering, and if the operation be a slight one, as the amputation of a finger or the removal of a small tumour, he may have half his usual diet allowed for a few days, but with little, if any, stimulant. If the operation have been more severe, but not capital, no solids should be allowed, but broths and nourishing liquids alone given for the first few days. If the operation have been a capital one, the patient's health and strength being otherwise good, he may be restricted to farinaceous slops and beef-tea until the febrile disturbance which always follows severe operations has passed off, after which some light pudding may be added; and the diet may, as the case progresses, be gradually improved by the successive addition of fish and the lighter kinds of meat, with a moderate quantity of stimulants, as required, until it reach the normal standard. It not

unfrequently happens, however, that a totally different course must be pursued. It is not my intention to enter upon the great question of the use and abuse of alcohol as an article of diet. But as a medicinal agent in severe surgical cases there can be no doubt of the great utility of alcohol in some shape. If the patient have been much reduced by long-continued suppuration, or other depressing causes before the operation ; if he be old and weakly in constitution, or have been in the habit of taking a very considerable quantity of stimulants, it will be absolutely necessary to adopt a tonic and stimulating mode of treatment. Indeed, in hospital practice especially, this is by far the most successful mode of treating patients after severe operations ; without it, many would have sunk, whom I have seen saved by the free administration of large quantities of brandy, wine, porter, eggs, and beef-tea from the very time of the operation—that stimulant being given to which the patient is accustomed in a state of health. This plan of treatment is also one of the best preventives of those diffuse forms of inflammation that are so commonly fatal in these cases ; and when they come on, I know no better remedy than the brandy-and-egg mixture, freely administered. In all this, however, the Surgeon must be guided by the patient's pulse, his previous habits, and the strength of his constitution ; and nothing requires greater judgment than the administration of stimulants, according to these particulars. The temperature is also a most important guide to the diet of a patient. If it be high, animal food must be avoided, but stimulants need not necessarily be abandoned ; in fact they may be required in increased quantity, especially if with the fever there is rapidity and weakness of the pulse. The great importance of attending scrupulously to the general cleanliness of the patient, and to the ventilation of the ward or room in which he is lying, as the best means of preventing the occurrence of unhealthy and spreading forms of inflammation, need scarcely be insisted on, as these hygienic precautions are universally recognised as being of the first importance under such circumstances.

The **remote effect** of the major operations is a subject that requires investigation. Do people who have undergone any of the greater operations, and who have recovered from the immediate effects, as a rule, live as long as those who have not sustained a mutilation ? I am disposed to think that they do not. When we reflect on the enormous number of persons who, before the age of thirty, suffer amputation of one of the limbs for injury, it is remarkable how seldom one sees an old person in a hospital or elsewhere, who has lost a limb in early life. I am, of course, speaking only of amputations for injury ; for those who have undergone this operation for strumous or malignant disease, frequently die early from recurrence of the constitutional vice in other parts of the body. So also with respect to lithotomy. Very many boys are cut for stone every year and recover ; but I scarcely recollect to have met with a middle-aged adult who had been operated on in childhood.

The various Special Operations will be considered when treating of the several Injuries and Diseases for which they are required ; but, as Amputations do not readily fall under any special head, being required for a great variety of different conditions, it will be more convenient to consider them here.

CHAPTER II.

AMPUTATIONS AND DISARTICULATIONS.

The term *Amputation* means the separation or removal of a part of the body. It is most commonly applied to the removal of a limb, but sometimes also to that of other parts, as the breast or penis.

The frequency of amputation of the limbs has much lessened of late years; other and less severe modes of treatment being now successfully followed in many cases of diseased joint, of aneurism, and of compound fracture. Still amputations are among the most frequent operations in surgery, and will continue to be so as long as the human body is liable to severe mutilations, to gangrene of the limbs, and to malignant and other incurable diseases of the bones and joints. It has been somewhat the fashion to decry amputation; and to speak of this operation as an opprobrium to curative surgery. But, though no Surgeon can deprecate unnecessary amputations more strongly than I do, I cannot admit that the removal of a limb is an operation of less merit than any other proceeding adopted when all other means have failed in curing the diseased part, or in saving the patient's life from danger. Surely, it is rather a subject of just pride than the reverse, that the Surgeon is able to save the whole of the body by sacrificing by a simple operation a limb that has been utterly disorganised or spoilt by disease or injury. In the performance of an amputation, also, much dexterity may frequently be displayed; and there is commonly great scope for surgical skill in the constitutional treatment of the patient both before and after the operation.

The amputation of a limb is generally performed through the continuity of a bone; when done at a joint, it is called a *Disarticulation*.

Amputation for diseases of joints, or for the immediate effects of injury, is an operation of comparatively recent date; for the older surgeons undertook the removal of a limb only for gangrene. So much was this the case, that in the works of many of the older writers the only mention of amputation is in the treatment of gangrene. Hippocrates, who lived about 400 years before Christ, recommended that the Surgeon in removing a gangrenous limb should limit his incisions to the dead tissues in order to avoid the danger of bleeding. Celsus, who lived at the commencement of the Christian era, encouraged a bolder line of practice. The operation of amputation as described by him was thus performed. A deep incision was made to the bone between the living and dead tissues, encroaching rather on the living than leaving any of the dead. When the bone was reached, the sound flesh was drawn back from it, and the saw applied as high as possible. The edges of the skin were then brought down and it was recommended that the covering should be lax, that it might as nearly as possible cover the bone completely. As, however, Celsus advises that the part which the skin did not reach should be dressed with lint covered with a sponge squeezed out of vinegar, it is probable that in many cases at least the covering was not sufficient to make a perfect stump. Celsus was acquainted with the use of the ligature, and wrote strongly against the employment of

caustics for the arrest of hæmorrhage ; it is probable, therefore, that the vessels were secured in an amputation at that time by the ligature, although no distinct mention is made of it in the description of the operation. In spite of this he tells us that the operation was attended by very great danger, for the patients often died from hæmorrhage or faintings during its performance, and that it was justified only by the fact that the cases for amputation were such that it had not to be considered whether the remedy was very safe, because it was the only one there was. Amputation was performed in this way, however, in spite of its dangers, till the beginning of the second century, when Archigenes, another Roman surgeon, invented the fillet, which was bound tightly round the limb to diminish the loss of blood. The writings of this Surgeon have been in great part lost, so that it is doubtful what means he used for the arrest of hæmorrhage; but, whatever they were, they do not seem to have been very successful ; for, soon after his time, Galen, who practised in Rome during the later part of the second century, reverted to the practice of Hippocrates, recommending that in amputations the incisions should be limited to the gangrenous tissues, and that a cautery should be applied to what remained of the dead parts after removal of the limb. The practice of tying arteries also fell completely into abeyance, the cautery being almost the only means employed for the arrest of hæmorrhage. So great indeed was the fear of hæmorrhage that, in the fourteenth century, Guido di Cauliaco recommended even strangulating the limb by means of plasters, and allowing it to drop off, in preference to any cutting operation. It was not till 1520 that the mode of operating adopted by Celsus was revived by Hans von Gersdorf ; but as the cautery, or various more or less impotent styptics were still the only means employed to stop the bleeding, the operation was too dangerous to be undertaken as an ordinary mode of treatment. Towards the latter part of the sixteenth century, about 1560, the use of the ligature was re-introduced by Ambroise Paré, the most celebrated Surgeon of his time. Amputation, as he performed it, was essentially the same operation as that described by Celsus, and although the arrest of bleeding was efficiently carried out by the ligature, the loss of blood during the operation was considerable ; for, though "the fillet" was bound tightly round the limb with the intention of diminishing the hæmorrhage, it seems never to have been applied with sufficient force completely to arrest the circulation. The instruments used for seizing the vessel were somewhat clumsy, and consequently the patient often lost so much blood before the vessel was tied, that the majority of Surgeons continued to prefer the cautery or some styptic for another century. It was not until the beginning of the eighteenth century that the ligature really became the only recognised mode of arresting arterial bleeding. This result was brought about partly by the discovery of the circulation of the blood by Harvey in 1628, but chiefly by the invention of a really efficient tourniquet by Morel in 1674. Surgeons now were able to perform amputations without the fear of seeing their patient die of hæmorrhage during the operation, and from that time the real improvement in amputations commenced.

In 1679, Lowndham, an English Surgeon, first suggested the plan of cutting a flap which could be made to cover the divided end of the bone, so as to obtain early union without separation of the end of the bone. Thus there came to be two distinct modes of amputating a limb, the circular and the flap method, each of which underwent gradual development and improvement.

Amputation by the Circular Method.—The first improvement of the circular method of amputating, made after the invention of the tourniquet, was the introduction of what was known as the operation "by the double incision." This mode of operating was introduced into practice almost simultaneously by Cheselden, of London, and J. L. Petit, of Paris. In this mode of operating, the skin and fat were divided by a circular incision; the assistant then, grasping the limb, pulled the integuments forcibly upwards, and the muscles were cut through to the bone by another circular sweep of the knife, and the saw applied as high up as possible. This method of operating did not aim at completely covering in the bone, but it provided such an amount of covering that it was possible for the stump to heal completely by granulation, usually after separation of the protruding end of the bone. The results of this operation were not so bad as might have been expected. The first Monro, who wrote in 1736, tells us that out of ninety-nine cases of major amputation performed by himself and his colleagues in the Edinburgh Infirmary, only eight died, and none of these from the immediate effects of the operation. Monro secured the vessels by ligature, and dressed the raw surface of the stump with dry lint, which remained on till it was loosened by suppuration. A modification of the operation by the double incision was introduced by the French surgeon, Louis, in 1768. He noticed that in making the circular incision through the muscles, the retraction of the superficial layers was greater than that of those near the bone. In order therefore to obtain a higher and more level division of the muscles, he divided the superficial layers with the skin and fat, and having drawn them forcibly upwards, cut the remaining muscle with a second sweep of the knife. A linen retractor was applied between the first and second incisions, and in order to allow the muscles to retract to the fullest possible extent, Louis was inclined to abandon the tourniquet and to trust to digital compression of the main arterial trunk. So far, Surgeons had advanced little beyond the operation of Celsus; in fact, it is doubtful whether in amputation by the double incision, as performed at this time, the bone was better covered than in that by the Roman Surgeons, who raised the soft parts very freely before sawing. The first attempt to diminish the size of the raw surface left after amputation was made by Samuel Sharp about 1750. He passed two broad ribbon-like ligatures, each composed of eight well waxed threads, through the edges of the wound about three-quarters of an inch from the margin of the skin, and drawing them tolerably tightly, tied them in a bow-knot. It was soon found, however, that the tension thus caused produced such an amount of pain and fever that the plan was abandoned almost as soon as it was recommended.

Between 1770 and 1780 the great fact became recognised that the only way to obtain speedy healing of a stump is to provide sufficient covering to enable the edges of the skin to be brought together over the end of the bone, so as to meet easily without tension. This led to the invention of the mode of operating known as amputation by the triple incision, which was introduced into practice almost simultaneously by Benjamin Bell, of Edinburgh, William Hey, of Leeds, and Alanson, of Liverpool. The two former performed the operation exactly as it is done in the present day by those who practise that method (Figs. 20 and 21). The skin and fat were first divided by a single sweep of the knife and dissected up for a distance equal to half the diameter of the limb; the muscles were then divided by another circular sweep of the

knife and retracted for a distance varying from one to two inches, according to the thickness of the limb; and the bone was sawn as high up as possible. In the thigh and leg it was recommended by Hey to cut the posterior muscles

Fig. 20.—Amputation of Arm by the Circular Method. Commencement of first incision.

longer than the anterior, to allow for their greater contraction. The edges of the skin were brought together in the transverse diameter of the limb, and a stump was formed with abundant covering for the bones, but necessarily with some puckering and projection at each angle.

The three incisions which gained for this operation the name of "the triple incision" were first the incision through the skin and fat, secondly, the incision through the muscles, and finally, the circular sweep round the bone to separate the muscles for retraction. The method adopted by Alanson produced much the same result, the only difference being that he attempted to divide the muscles in such a way as to leave a hollow cone with the bone at its apex, by turning the edge of the knife obliquely upwards. This proceeding was found by other Surgeons to be inconvenient, although in Alanson's hands it produced excellent results.

Amputation by the Flap-Method was invented in this country by Lowndham, and was first described in a work by J. Yonge, with the extraordinary title of "Currus Triumphalis e Terebinthino," published in 1679. The operation was at first performed only in the leg, and the flap which was formed from the calf was cut by dissection, and composed chiefly of the integuments and subcutaneous tissues. In 1696 Verduin of Amsterdam independently invented a similar operation, but his method differed from that of Lowndham in the flap being cut by transfixion, instead of being raised by dissection. Both Lowndham and Verduin hoped to be able to arrest

hæmorrhage by pressing the flap against the ends of the bones and securing it by bandages. The result was, that although in a few cases, especially in the hands of Yonge, who understood the necessity of drainage, union by first intention seems to have taken place, in the great majority the discharges were pent up and caused violent inflammation. In consequence of the unsatisfactory nature of the results obtained, the method was completely abandoned till 1739, when it was

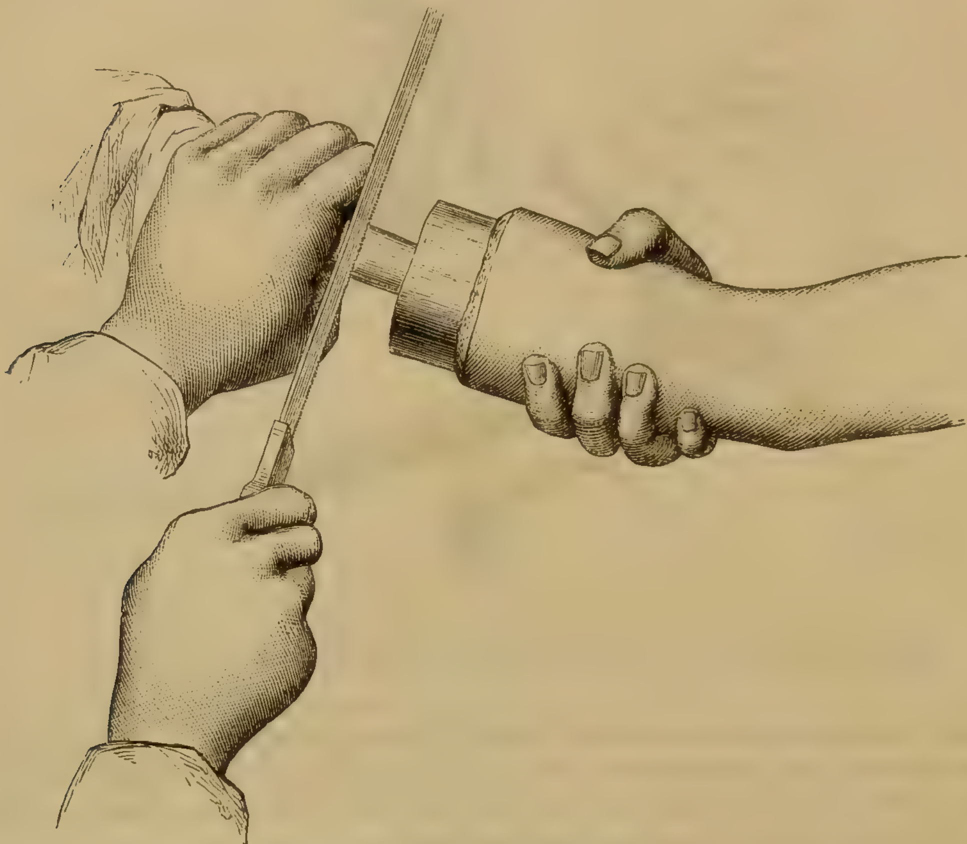


Fig. 21.—Amputation of the Arm by the Circular Method. Sawing the Bone.

re-introduced by a French surgeon of the name of Ravaton, who modified the operation by making two rectangular flaps, one from each side of the limb, and securing the vessels by means of the ligature. A similar operation was performed by Vermale, of Mannheim, in 1767, in the lower part of the thigh. That the flap method still did not yield very favourable results, on account of the tendency to accumulation of discharges between the flaps in the absence of any proper system of drainage, is evident from the fact that in 1765, O'Halloran, "surgeon and man-midwife" at Limerick, recommended that the flap and stump should be dressed as separate sores, and that they should not be brought together till the surfaces were covered by granulations. This plan did not, however, find much favour, and at the end of the last century Surgeons preferred the circular amputation in most cases, the flap operation being restricted almost entirely to the upper part of the leg, the lower part of the thigh, and the distal parts of the foot. Alanson and Hey, whose names have already been mentioned in connection with the circular method of amputation, practised and improved the flap operation in these situations.

During the first forty years of this century, however, the flap-operation came greatly into favour in this country, and was during the later part of that time supported by the able advocacy of Liston, who invariably amputated by that method, and who certainly did it with wonderful rapidity and precision. Amputation by the double flap as it is still practised, is thus performed (Fig. 22).

The two flaps may be made either by cutting from without inwards, or by transfixion—cutting from within outwards. Transfixion is adapted only to fleshy parts, as the thigh or arm; but cutting from without inwards will be found to afford the best result, and is indeed the only mode of forming the flap, in some situations in which the bones are naturally thinly covered, as on the

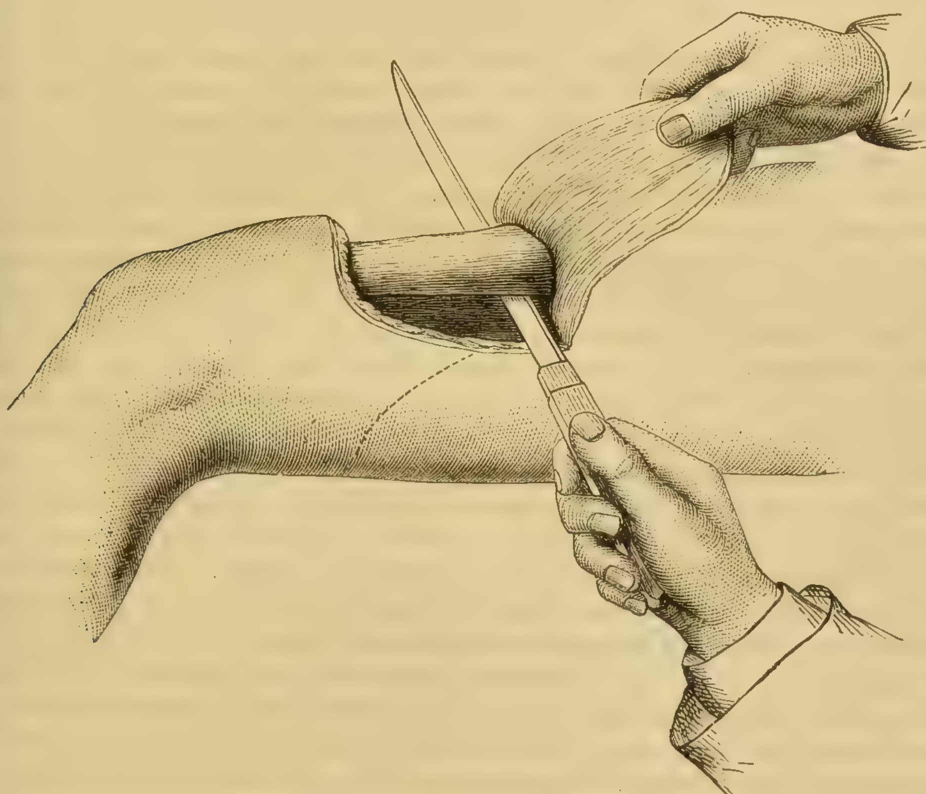


Fig. 22.—Amputation of the Thigh. Antero-posterior Flap-Operation. Flaps cut by Transfixion.

dorsal aspect of the fore-arm, the anterior part of the leg, or just above the ankle-joint, or where the soft parts have been wasted by chronic disease.

The flaps in transfixion should be made by a steady sweeping cut, so that the soft parts may be evenly and smoothly divided. Their length must of course be proportioned to the thickness of the limb. If they be cut too long, too much muscle will be left on the stump, and the flap itself is usually badly fashioned and pointed. Should the Surgeon feel that he has made this mistake, the wiser plan will be at once to round off the ends of the flaps. Should they have been cut too short, the soft parts must be forcibly retracted, the bone cleared by circular sweeps of the knife, and sawn as high up as possible. The flap farthest from the vessels, as that on the outer side of the thigh or arm, should be cut first. In making the inner flap, great care must be taken to wind the point of the knife well round the bone, so as not to transfix and

split the vessels, but to cut them as long as possible. As a general rule, the less loose muscle that is left on the stump, the better: hence, where there is an equal thickness of soft parts round the bone, as in the arm and thigh, the flaps should be cut short, well retracted, and the bone cleared by circular sweeps of the knife as high as necessary. The bone thus lies at the bottom of a deep hollow beyond the angle of junction of the flaps, and there is less chance of a conical stump being left.

In cutting a flap from without inwards, it is of the greatest importance to remember that the edge of the knife must never be turned towards the under surface of the flap, but always towards the parts to be removed. After marking out the flap with the point of the knife, the Surgeon takes the edge of the skin lightly between the finger and thumb of his left hand, and raises it from the parts beneath. The portion of the flap which is thus raised is therefore at right angles to the surface of the limb, and the knife must also be kept in a similar direction, or its edge will be turned towards the base of the flap, and by scoring its under surface will greatly increase the dangers of sloughing. The flap must be raised evenly across the limb, and one side must not be allowed to get in advance of the other. When bands of areolar tissue are seen passing from the flap to the parts beneath, the operator must divide these at the end that is attached to the parts to be removed. There should be no hurry about raising a flap by dissection, as under the influence of anæsthetics the lengthening of the operation by two or three minutes is a matter of but little importance. It is better to spend one or two minutes more over the operation, than to have to re-amputate on account of sloughing of the flaps.

The simple circular and the double-flap operations being thus brought to perfection marks the limits of the improvements in amputation which resulted from the invention of the tourniquet; and before the invention of anæsthetics Surgeons were divided in opinion as to which of the two methods was to be preferred when the nature of the case allowed of a choice. The advocates of the flap operation claimed for it the following advantages: that it was easy of performance, and could be carried out with great rapidity, thus saving pain to the patient; that the thick muscular cushion left over the ends of the bones made a better covering and rendered protrusion of the bone less likely to occur; and that the accuracy of fit obtained by this method favoured union of the flaps by first intention. The advocates of the circular method maintained: that the light covering formed by the skin and fat was less likely to be displaced by the involuntary movements of the muscles, and was quite as capable of uniting by first intention as fleshy flaps; and that protrusion of the bone was not dependent on the method adopted, but upon insufficiency of covering. As long ago as 1783 it had been pointed out by Mynors that the muscular cushion was more an ideal advantage than a real one; for in course of time the muscular tissue in the flap becomes atrophied and absorbed, until after a few months the difference in covering between a stump formed by the flap method and one by the circular is inappreciable. The advocates of the circular method also maintained that the vessels being cut transversely retract more perfectly, and are less likely to bleed afterwards, and that the wound resulting from the operation is smaller than that produced by the flap method. The great objection to the circular operation was undoubtedly its tediousness and painfulness, and consequently the flap operation became undoubtedly the favourite with most Surgeons. The invention of anæsthetics, however, left the Surgeon

free to consider solely what method of amputation furnishes the best results. Hence many plans of operation that were almost discarded thirty years ago have regained their ascendency, and flaps are now most frequently carved out by cutting from without inwards, regardless of the greater length of time required provided the result is more satisfactory.

As a result of the thought and labour devoted to the improvement of amputation since the invention of anæsthetics, certain general principles have come to be universally recognised as guiding the Surgeon in the performance of the operation. These may be briefly stated thus :—

1. The covering must be sufficient to meet over the bone without the slightest tension ;

2. The amputation should be so performed that the scar, when the stump is healed, shall not lie over the end of the bone ;

3. If possible, a dependent opening shall be provided for the exit of the discharges ;

4. That these advantages shall be obtained with the smallest possible sacrifice of the healthy parts of the limb.

Each of these requires consideration more in detail.

1. To provide a sufficient Covering.—It was long ago pointed out by Mynors and others, that the standard by which we must estimate the amount of covering required is the diameter of the limb at right angles to the line in which the cicatrix is to be placed, and taken at the point at which the bone is to be divided. In operating on the dead body, it is evident that if two equal flaps, each measuring half the diameter of the limb at the point at which the bone is sawn, were cut, they would meet accurately and cover in the bone ; but such flaps in the living body would be totally inadequate on account of the shrinking from the elasticity of the skin and the displacement from the contraction of the muscles. Consequently, it is necessary to provide another half diameter of covering *at least*, and in some situations even this amount is barely sufficient. As an illustration of the above rule, let us suppose a limb is to be amputated, the antero-posterior diameter of which, at the point where the bone is to be sawn, is six inches, the necessary diameter and a half of covering could be obtained in the following ways amongst others :—1. One long flap nine inches long ; 2, two flaps, one six inches long and the other three ; 3, two equal flaps four and a half inches long ; 4, two equal flaps three inches long, and retraction of the muscles from the bone to such an extent as to provide an inch and a half of covering on each side ; 5, a circular incision raising the skin and fat for three inches, and another circular cut through the muscles with retraction of the soft parts from the bone for one inch and a half.

The general rule that one diameter and a half is sufficient, requires modification under various conditions of the tissues of which the covering is made, and in various situations. In very old people the skin has frequently lost much of its elasticity ; but it is not wise to shorten the covering on this account, as the tissues being feeble are less capable of withstanding the irritating effect of tension. In amputation through chronically inflamed tissues, the retraction is also reduced to a minimum on account of the rigidity of the parts ; but here again it is unwise to shorten the covering—in fact it is better to make it a little longer—as the flaps are very apt gradually to shrink during or after the healing of the stump. In limbs in which the muscles have undergone extreme

fatty degeneration, the retraction caused by their tonic contraction is absent, so that the minimum covering of a diameter and a half is amply sufficient. In the lower third of the thigh the covering should always be increased to two diameters to allow for the very excessive retraction of the long flexor muscles of the leg. In amputation of the leg by the long calf-flap, it is also necessary to provide very abundant covering to allow for the subsequent shrinking of the muscular tissue which forms the posterior flap.

2. That the scar shall not be over the end of the bone.—It is evident in the first place that protrusion of the bone is more likely to occur if the two flaps in a flap amputation meet exactly over its end; but the chief object in placing the scar so that it shall be free from the bone is to avoid a painful stump. If the scar in the skin is adherent to the bone it becomes extremely liable to ulceration from slight injuries. If the scar be placed well away from the bone, it is often possible in amputations of the lower limb for the patient to bear a certain proportion of his weight on the end of the stump, which gives greatly increased steadiness in walking on an artificial limb.

3. That a dependent opening is to be provided for the exit of discharge.—May be stated in other words thus: that the covering of the stump shall be taken chiefly from the dorsal surface of the fore-arm, and from the anterior part of the limb elsewhere. Perfect drainage is absolutely essential for union of any wound by first intention, and consequently it is needless to point out the importance of so arranging the covering that the force of gravity shall aid, and not oppose, the escape of discharges. In exceptional cases, such as in some of the amputations in the foot, the advantages of the flap taken from the heel or sole in providing a covering upon which the patient can bear his whole weight are sufficient to counter-balance the difficulty of drainage that sometimes is met with in these operations. If the covering be taken chiefly from the front of the limb, it is evident that not only will gravity aid in draining the wound, but also that it will tend to keep the longer flap in its position. If the covering be taken chiefly from behind, as in the transfixion-amputation in the leg, the tendency of the heavy muscular flap to fall backwards can be counteracted only by fixing it to the anterior by sutures or strapping; tension of the short flap is produced and it may slough over the bone; any insufficiency in external support allows the posterior flap to fall away, fluids bag in the gap, and speedy union is impossible.

4. That these advantages are to be gained with the smallest possible sacrifice of the length of the limb.—Experience has shown conclusively that the danger of an amputation increases as the point at which the bone is sawn approaches the trunk. No fact in surgery is more conclusively proved than this. It is evident that the bone can be sawn at the lowest possible point if the covering is taken equally from the two sides. To take as an example a limb the antero-posterior diameter of which is six inches, and which consequently requires nine inches at least of covering to form a good stump, and supposing the nature of the case made it impossible to obtain covering from a point lower than the end of the bone to be sawn through, if it is to be taken equally from the two sides, the bone would be sawn four-and-a-half inches above its lower end; if from one side only, nine inches. If, however, the anterior flap was five-and-a-half inches long and the posterior three-and-a-half, the advantages of a dependent opening and a scar removed from pressure could be obtained with the sacrifice of only one inch

more bone than if the flaps had been of equal length. The Surgeon will therefore adhere to the rule of taking the covering as equally as possible from the two sides of the limb only so far as is consistent with the other essentials of a good amputation—a dependent opening for drainage, and a scar away from the bone. A long stump is more easily fitted with an artificial limb and gives the patient greater control over it.

These essential features of a good amputation being agreed upon, the questions of the best material of which to form the covering, and the best way of raising it, remain to be considered.

All Surgeons are now agreed that too much muscle in a flap is an unmitigated evil. The objections to muscular flaps are, that they are heavy, and consequently liable to be easily displaced; that, supposing any voluntary movement or involuntary jerking or twitching of the limb to occur, the surfaces of the flaps are moved upon each other, and primary union is thus prevented, and that this is especially likely to happen if the sharp edge of the sawn bone is in direct contact with a muscular flap bent over its end; that muscular flaps retract to a considerable extent after the operation, and continue to shrink for some time, thus causing a greater tendency to protrusion of the bone; and, lastly, that as in the end the muscle completely wastes away, the idea that a muscular flap forms a better cushion than one composed of the skin and subcutaneous fat only is erroneous. None of these objections can be raised to a covering composed solely of the cutaneous and subcutaneous tissues; but, on the other hand, in very emaciated subjects, such a covering is very thin, and is apt to suffer from the direct pressure of the bone against it, and consequently in such cases it is well to protect it by raising a certain amount of muscle with it. Skin flaps also, if very long, are apt to slough, as their vascular supply is somewhat limited, and this accident is especially liable to happen in old people. In any patient, whether young or old, fat or thin, sloughing will almost certainly occur if the Surgeon turns the edge of the knife towards the flap instead of keeping it directed towards the parts to be removed. Common sense would suggest also that it is wise to thicken the base of a flap with a little muscle when possible, if circumstances require it to be made of more than ordinary length. If the covering in most parts were made solely of skin and fat, the retraction of the muscles would leave the bone protruding sharply beneath the flaps, and the object of the Surgeon is therefore to save so much muscle that after full retraction has taken place it shall still be level with the sawn end of the bone. In order to obtain this result, the proportions usually sufficient are to provide one diameter of covering composed of the skin and subcutaneous structures, and half a diameter of muscle, or more if the retraction is expected to be considerable, as in the lower part of the thigh. In all cases the operator should bear the principles in mind, and be guided in his performance by circumstances, considering the age and state of health of the patient, the amount of subcutaneous fat, the length of the flaps, and the situation of the amputation, and suiting the relative proportions of skin and muscular covering to the nature of the case. A mere mechanical amputator can never be a good one.

In amputating for diseased joints, it often becomes a question whether the structures covering the articulation are in a fit state to be used in the formation of flaps. As a general rule, it may be stated that the chronically inflamed tissues covering a diseased joint, even when perforated here and there by

sinuses, form excellent flaps ; but it must be borne in mind that, their vitality being somewhat lower than natural, they must be carefully handled to avoid unnecessary bruising, and that they are liable to shrink considerably as the stump heals, and consequently their length must be slightly greater than if the tissues were healthy. Such flaps yield a large amount of serous exudation during the first few hours after the operation, and ample drainage must be provided for this.

The Mode of Raising the Covering.—This may be done by cutting from within outwards, or from without inwards—in other words, by transfixion or by dissection. Most Surgeons now prefer the latter method, the objection to transfixion being that it leaves the Surgeon no choice as to the relative amount of skin and muscle that he will take in his flap, and is consequently ill suited for all amputations in muscular subjects. Its chief advantage was its rapidity, and since the invention of anæsthetics this is of little or no consequence. A minor advantage is, that it is less difficult of performance than cutting from without inwards, but the amount of skill required for the latter is not such as to justify any Surgeon in resorting to the former method on that account.

The covering, as before stated, may be raised circularly or in flaps. The relative merits of these two methods have already been discussed. In some of the modern methods of amputating about to be described, it has been the object of the Surgeons to combine, as far as possible, the advantages of both methods in one—following the rules just laid down as to the essentials of a good amputation.

Amputation by the Modified Circular Method.—In 1839, Liston proposed a combination of the double flap and circular operations, which

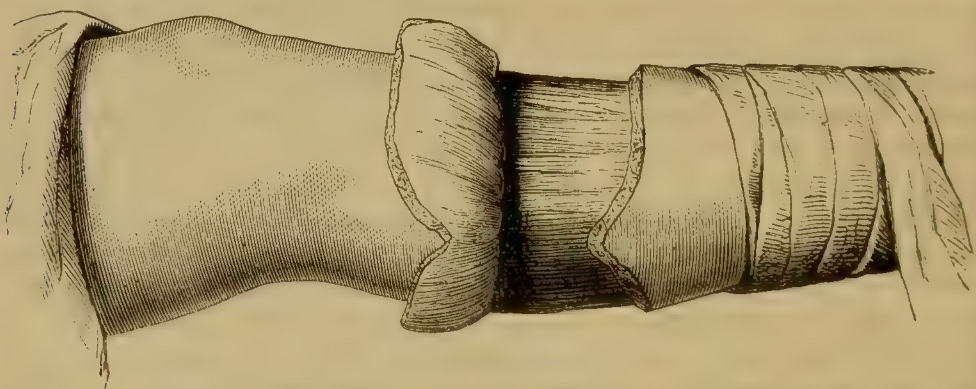


Fig. 23.—Modified Circular Amputation in the upper third of the Leg.

greatly improved the shape of the stump of the circular method, and somewhat increased the ease of the operation (Fig. 23). Two semilunar incisions, with their convexities downwards, are made through the skin from side to side of the limb : the flaps are then dissected up so as to expose the muscles somewhat higher than the angles of union of the flaps : and the operation is completed as in the ordinary circular method. This method of operating is especially indicated in muscular parts, such as the arm, thigh, or leg. The advantage of this procedure over the ordinary flap-operation is very great in stout muscular subjects.

Amputation by the Long Anterior Flap.—The late Mr. Teale of Leeds, in 1853, invented and practised a mode of amputation by a long

anterior and a short posterior rectangular flap. The long flap is perfectly square, and the rule for its formation given by Teale is, that its length and breadth should each be equal to half the circumference of the limb at the place at which the bones are to be sawn (Fig. 24). If the circumference be 12 inches, the length and breadth of the flap, both at its base and at its free extremity should be 6. The short flap cut from the posterior aspect of the limb, or the palmar aspect, if the operation be in the fore-arm, is to be one-quarter the length of the anterior flap; in the case above supposed it would be $1\frac{1}{2}$ inches. In performing the operation the measurements must be carefully made, and the outline of the flaps marked on the limb with ink before the amputation is commenced. Both flaps are to be made to include all the soft parts of the limb, and the short flap will always contain the chief vessels and nerves. The bones are sawn exactly at the angle of union of the flaps, without any previous retraction of the soft parts. After the vessels have been secured, the long flap is folded over the end of the bone, and

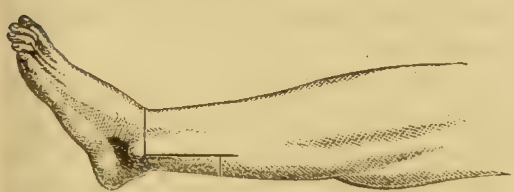


Fig. 24.—Lines of Incision in Teale's Amputation.

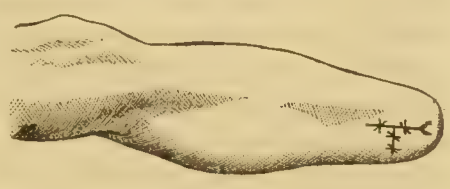


Fig. 25.—Teale's Amputation: Stump.

attached by suture, partly to the short flap, and partly to itself; thus the first quarter of the long anterior flap is first accurately sewn to the short posterior flap; the remaining part of the anterior flap is then doubled over on itself, its free end being accurately fitted to the free end of the short flap, and attached by sutures; finally stitches are applied where the terminal part of the flap is in contact with the second quarter, as in the figure (Fig. 25). The results of amputation by this method in Teale's hands were very satisfactory. The advantages claimed by Teale for his method of amputating were, that it provided an abundant covering free from tension. This it evidently does, as the covering amounts to $1\frac{7}{8}$ diameters of the limb. Secondly, it provides a dependent opening for the exit of discharge; and thirdly, that when it is healed the cicatrix is behind the bones, and that consequently the patient can bear the whole or a part of his weight on the end of the stump; this is especially advantageous after amputation in the thigh or leg, when direct pressure can scarcely be avoided, and when a solid firm stump admitting it is of very essential service to the patient. Teale advises, however, that the whole pressure be not borne by the stump, but that it be reduced to one-half, the remainder being distributed in the usual way on the upper part of the limb: thus not only relieving the stump, but securing greater steadiness of gait and firmness of step. In the upper extremity, however, no direct pressure is made upon the end of the stump in the adaptation of artificial limbs; hence, the rectangular appears in these situations to possess no advantage over the other double-flap methods, so far as the utility of the stump is concerned.

But, whilst fully admitting the advantage possessed by the rectangular method in the formation of a well-covered stump, especially in the lower extremity, we must not close our eyes to certain disadvantages which appear to

me to be inseparable from it. One disadvantage consists in the necessity of sawing the bone at a higher point when one long flap only is made, than when two shorter ones more nearly equal in length are fashioned. Thus, for instance, in an amputation of the thigh for injury about the knee-joint, the long rectangular flap in an adult would require to be about eight inches in length, and the femur must consequently be sawn at least as far as this above the patella: whereas, in the ordinary double-flap amputation, two shorter flaps, each about four inches in length, will be found sufficient to cover in the bone, which may consequently be sawn at a proportionately lower point. Thus the rectangular method contravenes the principle in amputation, not to remove the limb at a higher point than is absolutely necessary, the danger to life increasing with every inch that is removed: nor can it be considered to be advantageous in those cases in which length is essential to the utility of the stump and the comfort of the patient.

In amputations for malignant disease, also, the long flap, which has to be cut in close proximity to the morbid growth, would run a far greater risk of infiltration than would two shorter ones taken higher up in the limb: the bone in both cases being sawn at the same level.

Should union by the first intention fail and suppuration ensue, in the rectangular amputation the thick fleshy mass which enters into the formation of the long flap becomes a source of great inconvenience, bulging out from under the skin, and requiring considerable management in the after-treatment.

For these reasons the unmodified form of Teale's amputation is hardly to be recommended.

At the same time that Teale was recommending the long anterior flap in all parts of the body, Carden, of Worcester, was advocating its employment in a form of amputation invented by him for removal of the thigh immediately above the knee. In his operation, which will be described amongst the special amputations, a single long anterior flap was made, the extremity of which was rounded in form.

Spence of Edinburgh, who fully recognised the advantages of Teale's method of amputation in the lower third of the thigh, suggested a modification by which he hoped to obtain them with less trouble and without producing quite so large a wound. He made no posterior flap, but compensated for it by retracting the soft parts from the bones to an extent equal to its length. The anterior flap was to be made a little longer than the diameter of the limb: and its angles being rounded, it was allowed simply to hang over the end of the stump, without being folded upon itself as in Teale's operation. The posterior parts were divided from without inwards by a single sweep of the knife. By this method, however, the bone was sawn as high up as in Teale's method, so that the gain was not very great.

In 1860 Lister pointed out that the advantages of Teale's method could be obtained with considerably less sacrifice of length in the limb by taking the covering more equally from the anterior and posterior aspects. A dependent opening for the exit of the discharges, and a scar placed behind the bones may be obtained in almost all situations by making an anterior flap two-thirds of the diameter of the limb in length, and a posterior half that length, as the bone is in almost all parts situated more towards the anterior than the posterior aspect of the limb. In all parts of the limbs the flexors, being the muscles with the longer bellies, retract more extensively than the extensors;

and, consequently, if, when the operation is finished, the line of union of the flaps is to the flexor aspect of the bones, it is quite certain that the scar, when the stump is healed, will be in a similar position. The method of operating, therefore, recommended by Lister as best suited to the amputations of the forearm, leg, and thigh, is the following. An anterior rounded flap, equal in length to two-thirds of the antero-posterior diameter of the limb at the point at which the bone is to be sawn, is raised by cutting from without inwards. In the lower thirds of the leg and forearm the bones form so large a proportion of the limb that, in order to make sure that the scar shall be placed behind them, it is necessary to increase the length of the anterior flap to the diameter of the limb. In raising the anterior flap the operator will, if he think fit, try to take up some muscle at the base of the flap to thicken it up and so ensure its vitality. This is always to be recommended for all parts in thin or feeble subjects, and in the thigh in every patient. The flap is not, however, under any circumstances to be too fleshy and heavy. A posterior skin-flap, half the length of the anterior, is next raised. The muscles are then divided circularly and retracted from the bone for a distance equal to at least one quarter of the diameter of the limb; in the thigh it is better always to retract for half a diameter. It is evident that in the leg this retraction may be rather difficult, especially in secondary amputations in which the tissues are swollen and infiltrated; but the difficulty is easily overcome by extending the incision upwards from the angle of the flaps, either on one or both sides of the limb, to the point at which the bones are to be sawn. This mode of amputating combines the advantages of both the circular and flap operations; it has the light covering and absence of excessive muscle of the circular, with the accurate fit, the good drainage, and the well placed scar of the flap method. It is in fact a combination of the flap and circular operations, and is, therefore, sometimes spoken of as the "combination method."

Amputation by the Oval Method, which is especially adapted to removal of fingers or toes and disarticulations at the shoulder and hip, is essentially a circular amputation with a longitudinal incision made up one side of the limb, to facilitate the retraction of the soft parts and the exposure of the joint at which disarticulation is to be performed. The oval form is given by rounding off the angles formed by the junction of the longitudinal with the circular incision. When the longitudinal incision is continued for some distance above the commencement of the true oval part, the operation is frequently spoken of as amputation by the "racket-shaped incision."

Sawing the Bone.—In all methods of amputating, as soon as the incisions have been made through the soft parts, the bones must be cleared for the application of the saw. While doing this the soft parts must be firmly retracted by the assistant or by the Surgeon himself, if he stands so as to take his own flaps. For the purpose of retraction the hands are usually sufficient, though some Surgeons still use retractors made of pieces of stout calico or linen. The retractor must be about two inches wider than the diameter of the limb and about three feet long. If there is only one bone, one end must be torn into two tails. The retractor is soaked in carbolic lotion, and the two tails of the divided end are then passed one on each side of the bone and slightly crossed on each other. The assistant then, taking the two tails in one hand and the undivided end in the other, pulls them forcibly upwards. If there are two bones, the divided end must be torn into three tails, the

middle one of which is passed between the bones. Retractors are of use only in circular or combined flap and circular amputations. In the pure flap operations they are unnecessary for retraction of the soft parts, but they are still of use in protecting the muscles from the teeth of the saw and in keeping the surfaces free from the bone-dust: for the laceration of the deep muscles by the saw and the imbedding of bone-dust in their substance, interfere seriously with union. If a retractor is used, the final clearing of the bone is completed after it has been applied. This is best done, when there is only a single bone, by a firm circular sweep of the knife from heel to point round the under segment of the bone, and then another round the upper surface in the opposite direction. If there be two bones, care must be taken in clearing them not to direct the edge of the knife upwards into the interosseous space higher than the line to which the saw is to be applied, lest any artery be cut where it will, on account of its retraction, be difficult to secure it.

The bone having been properly cleared, the flaps must be firmly retracted, in order to allow the saw to be applied opposite the highest point of the incision through the soft parts. In order to saw the bone quickly and steadily, there are several points deserving attention. The first cut should be made so as to form a deep groove to receive the teeth: to do this, the heel of the saw is steadied against the left thumb, which is pressed on the bone, and the instrument is drawn fairly and sharply along the whole line of its teeth from heel to point. The groove thus formed receives the edge of the saw: and the bone may then be quickly cut through by long, light, and sweeping movements of the instrument from point to heel, the position being gradually changed from the horizontal to the vertical as progress is made. The assistant must carefully support the part to be removed; neither depressing it, so as to snap the bone as it is weakened by sawing; nor raising it so as to run the risk of locking the saw. When there are two bones of equal strength in the limb, as in the fore-arm, they should be cut through at the same time; but in the leg, the fibula, being the weaker, should always be first divided. Should the division be made irregularly, and splinters of bone project, these must be snipped off with cutting-pliers.

The Arrest of Hæmorrhage.—After the limb has been removed the first thing to be done is to restrain arterial hæmorrhage. The vessels are to be secured by some of the means described in Chapter XIV. The means most commonly adopted in the present day are torsion and ligature with prepared catgut, which may be left in the wound without fear of after-trouble. Whatever means of arresting hæmorrhage are adopted, all vessels visible on the surfaces of the flaps should be secured before the tourniquet is removed, the Surgeon being guided by his anatomical knowledge to the situation of the more important branches. In addition to the main trunk, from two to four or six smaller vessels usually require to be secured; but sometimes, either from the existence of malignant disease, or of extensive suppuration in the limb, the stump is excessively vascular, and a very large number of ligatures may be required. I have, in these circumstances, more than once had occasion to apply between twenty and thirty ligatures to vessels in the arm and thigh.

Free arterial bleeding will sometimes take place from a point in the cut surface of the bone, in consequence of the division of the trunk of the nutrient artery. This hæmorrhage is best arrested by pressing one or two strands of carbolised catgut twisted together into the canal; or, if this should

fail, it may be plugged with a small piece of carbolised sponge, which will become buried in the stump and absorbed almost as easily as the catgut. The old plan of inserting a wooden plug with a wire to it should never be resorted to if other means are available, as it is certain to serve as a centre of suppuration and causes disturbance of the wound when it is removed.

It is impossible to take too great care in arresting not only all arterial hæmorrhage, but all oozing of blood before closing the wound. It is to painstaking and patient arrest of every trace of bleeding that the great success of some Surgeons in obtaining primary union is in part to be attributed. To have to open up the wound to secure a bleeding vessel within an hour of the operation is one of the most annoying accidents that can happen to a Surgeon, and is most damaging to the prospect of speedy union of the wound,

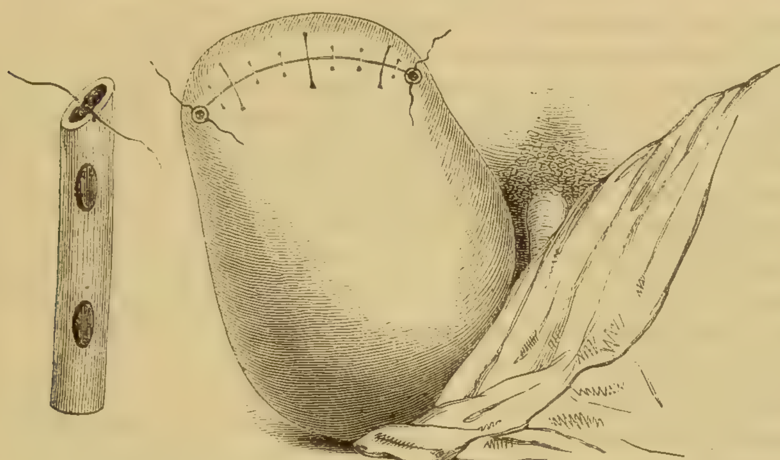


Fig. 26.—A Stump showing the mode of applying Suture and drainage-tube. A drainage-tube.

but even this is less injurious than the distension of the flaps with a coagulum, the result of oozing which, perhaps, stops just short of obliging the Surgeon to open up the wound for its arrest.

Closure of the Wound.—The hæmorrhage having been arrested, the covering is brought together over the bone by means of sutures. In a well-made stump the covering is so loose that no force of any kind is necessary to bring the edges together, consequently, adhesive plaster can scarcely ever be required. In cases in which a strictly antiseptic dressing is being used, unwaxed silk soaked for twenty-four hours in a 1-in-20 solution of carbolic acid, makes the best sutures. If the dressing is such that decomposition of the discharges is possible, it is better to use metallic sutures, as they do not absorb the septic matter, and are consequently quite unirritating if they are not tight. In inserting the stitches, it is better to put in two or three very thick sutures, either of silk or wire, at intervals of about one inch to one inch and a half (Fig. 26). They should get a good hold of the skin and fat for at least one inch from the edge of the wound. These bear any strain that may arise from swelling or retraction. Between them finer sutures must be inserted, at intervals of about half an inch, bringing the skin edges into accurate apposition. Such close sewing as this, however, would be fatal to any hope of union, unless a proper exit for the discharges is provided for by drainage-tubes. These are best made of indiarubber. There should always be one at each angle of the

stump, and, if it seems necessary from the size of the stump, a third should be inserted in the middle. The drainage tubes must be cut level with the surface of the wound, and above all it must not be forgotten to fit each with a couple of threads, one on each side of its orifice to prevent its slipping into the wound and being lost there—an accident which has frequently happened from neglecting this precaution.

Dressing the Stump.—An amputation leaves a clean-cut wound, which must be treated on those principles that guide the Surgeon in the management of all incised wounds, and which will be fully described in Chapter IX. They may be summed up briefly thus :—1. Removal of all coagulum, bone-detritus, or other foreign body ; 2. Close and accurate coaptation of flaps ; 3. Efficient drainage ; 4. Perfect rest of the part ; 5. Scrupulous attention to cleanliness—the most perfect cleanliness consisting in the absolute prevention of decomposition of the discharges. The most important methods of treating stumps are, the antiseptic dressing with carbolic gauze and the antiseptic cotton-wool (salicylic or iodoform wool) dressing. Good results have been obtained by some Surgeons with the so-called open treatment—that is to say, no dressing at all. Among the best results are those obtained by the late Mr. Callender. His method consisted essentially in the use of a drainage-tube for from twenty-four to thirty-six hours, placing the stump on a well-padded splint, to which it was bandaged, so as to prevent all voluntary movement and disturbance by involuntary twitchings, and dressing the cut edges with lint soaked in carbolic acid and oil and cleansing them when necessary with a glass brush dipped in a strong spirituous solution of carbolic acid.

No mode of dressing will, however, give good results unless perfect drainage is obtained by the use of tubes; and this is all the more essential in the present day because almost every Surgeon now washes the stump with some antiseptic solution, which, being necessarily an irritant, increases greatly the amount of the serous discharge for the first twenty-four hours ; and the old ligature with its ends hanging from the wound being almost completely abandoned, that source of drainage has disappeared. The amount of rest that a stump gets depends greatly upon the skill with which it is handled by the Surgeon at the dressing. The stump should be supported on a pillow, and the weight of the bed-clothes taken off by a cradle ; or should the covering be composed of heavy muscular flaps, it may advantageously be placed on a well-padded wire splint.

In some cases, although the flaps may appear abundant at the time of the operation, the retraction may much exceed that which was anticipated, and a wide granulating surface may be left after the deep parts have healed. This is most common in amputations in the thigh by antero-posterior flaps. If the flaps have really been of sufficient length, this will usually remedy itself, the contraction of the granulating sore gradually bringing the skin edges together again. The healing of the stump under these conditions is hastened by applying weight extension, which is done thus : a piece of diachylon plaster is cut of sufficient length to reach to the next joint above the amputation on the anterior and posterior aspects of the limb, and to form a loop extending at least one foot beyond the end of the stump. Its width at each end must be nearly half the circumference of the limb, and in the middle it may be somewhat narrower. The plaster is well warmed and applied to the stump, and surrounded by a few turns of a bandage, made of the best elastic Welsh flannel. A wide "spreader," made of a piece of wood with a hole in it for the rope which

supports the weight to pass through, is then put into the projecting loop of plaster. The spreader saves the end of the stump from being squeezed. The weight is then applied over a pulley in the same way as is described and figured under the treatment of fracture of the femur. The results of this treatment are most satisfactory, especially in the lower third of the thigh.

In most cases the stump is benefited by the application of a bandage to support and mould it during the final stage of cicatrisation ; and as a general rule, it will be found that a narrow roller will adapt itself better than a broad one. After cicatrisation is completed, the patient should be allowed to go about on crutches, but must not wear an artificial limb for some months, until the parts have become firmly consolidated ; during the whole of this time the stump should be kept carefully bandaged, and not exposed to injury.

In performing an amputation, the preparations directed on page 37 must be accurately carried out. The Surgeon must himself see that the **Amputating Instruments** are in proper order, and of good construction. For the smaller amputations the Surgeon will require straight bistouries, narrow or broad in the blade, according to the size of the part to be removed. Scalpels, also, not too broad in the blade, are useful in cases in which the bistoury, from its length, might be inconvenient. Cutting-pliers, with long and strong handles and short blades, either straight or curved as may be most convenient, are especially required in amputations about the hands and feet. The knives for the larger amputations should have smooth ebony handles, and be well balanced. The back of the blade should run straight to the point, and be well rounded. The edge should taper off towards the point, with a good convexity. The breadth of the blade should be from three-fifths to two-thirds of an inch, and its length should be proportioned to the size of the limb to be removed. In operating by transfixion in order to make a good sweeping cut, so as to form a well rounded and smooth flap, the blade should as a general rule, be about equal in length to double the diameter of the limb. For raising the flaps by dissection many Surgeons prefer shorter knives. The saw should be strong in the blade and back, so as not to bend in cutting. The blade must be of good breadth, and its teeth must be well set so that it shall not hang as it works its way through the bone. Artery-forceps of the ordinary bull-dog kind, and torsion-forceps will be required ; and some half dozen of Spencer Wells's forceps should always be ready for the temporary arrest of hæmorrhage from the smaller branches while the larger are being secured.

Simultaneous or Rapidly Consecutive Amputation of Two Limbs, requiring removal for severe injury or for gangrene, has occasionally been successfully practised, either by two Surgeons performing the two amputations at the same time ; or by the same Surgeon doing first one and then the other, the vessels of the first limb being secured by an assistant whilst the second limb is being removed. The circulation through both lower extremities may be completely arrested by compressing the aorta with Pancoast's tourniquet. By means of this valuable instrument, I have amputated both thighs in close succession without waiting for the ligature of the arteries in that which was first removed. The object in two simultaneous amputations is to lessen the continuance of shock to the system, by throwing, as it were, that of the two operations into one. In doing this, however, the Surgeon

must necessarily be guided by the circumstances of the case. If the patient were very greatly depressed, the infliction of so severe an injury as a double amputation might probably extinguish life at once; and, if it were possible to wait after the removal of the first limb, until the shock of the operation had passed off, before the second was amputated, it might be desirable to do so; but if the patient were not too much depressed, the simultaneous or rather rapidly consecutive double amputation would probably be the safer course.

STUMPS.

On examining the structure of a stump after one or two years have elapsed from the time of its formation, it will be found to be composed of a mass of fibro-cellular tissue, any muscular substance which may have entered into its formation having completely atrophied and disappeared. Any tendons which may have been divided will be either lost in the fibrous tissue of the scar, or will be found to have formed new attachments to the bones. The end of the bone is rounded and the medullary canal closed by a layer of compact bone. The vessels are obliterated as high as the nearest branch and converted into fibrous cords. The ends of the nerves are thickened, and commonly assume a bulbous form (Fig. 27). On examining these rounded or oval tumours they will be found to be composed of fibrous tissue, among which are great numbers of new nervous fibrillæ twisted and rolled upon each other in all directions.

Fig. 27.—Endings of Nerves in a stump.

The proper adaptation of **Artificial Limbs** is a matter of considerable consequence; and the ingenious contrivances that are at the present day applied to stumps, leave little to be desired. The Surgeon had better leave the details of these mechanical contrivances to the instrument-maker; but he should see that they are made light, consistently with sufficient strength and support, and that the end of the stump is never injuriously pressed upon by them. Thus, after amputation of the thigh, the artificial limb should take its chief bearing point from the lower part of the pelvis and hip. In amputation immediately below the knee, this joint should be bent and received into the socket of the instrument; and, if the amputation be at a lower point than this, and the stump be extended into the artificial limb, its end must be protected from injurious pressure.

In all amputations of the lower limb in which the Surgeon has succeeded in producing a satisfactory loose covering, not adherent to the bone, and with the scar well behind it, the patient should be encouraged to bear part of his weight, at least, directly on the end of the stump. Not only does this give increased steadiness in walking, but it is said to diminish the tendency to excessive atrophy of the soft parts which sometimes occurs in old stumps. The plan recommended by Teale of gradually accustoming the end of the stump to bear pressure will be found most satisfactory. The patient must prepare a number of circular pieces of flannel of the same diameter as the socket of the artificial limb. He first puts in a sufficient number of these to form a pad just touching the stump—after this he adds one daily till the stump becomes accustomed to bear the necessary degree of pressure. In all amputations through the knee joint or condyles of the femur, and in Symes

or Pirogoff's amputation at the ankle, the patient should be able to bear his whole weight on the stump without difficulty.

Morbid Conditions of Stumps.—**Septic osteo-myelitis,** that is to say, septic inflammation of the medulla of the bone, when the canal has been opened in removing the limb, is one of the most serious accidents that can happen after an amputation. It most frequently occurs during the second or third week after the operation. The symptoms and pathology are fully described in the Chapter on Diseases of Bone. It was formerly a frequent cause of pyæmia. With the present improved treatment of amputation wounds it has become excessively rare.

Fig. 28.—Necrosed end of Femur from Stump.

Fig. 29.—Extreme case of Conical Stump.

Necrosis.—It not unfrequently happens that a small scale of bone which has been injured by the saw dies, and is separated some three or four weeks after the operation. This occurs most frequently in those stumps which unite by second intention, and in which the bone consequently lies bathed in pus for a considerable time. It is to be prevented by adopting such means of dressing as shall ensure union, at any rate of the deeper parts, by first intention, and the chances of its occurrence are reduced to a minimum if decomposition of the discharges is prevented. Great care must also be used in sawing the bone not to denude it needlessly of its periosteum.

More extensive necrosis used to be a frequent consequence of septic osteomyelitis, where the patient escaped the fatal complication of pyæmia, but under the improved systems of dressing it is comparatively rare. In such cases fistulous openings will be left leading down to the necrosed bone, which usually separates three or four months after the operation, after which the stump becomes firmly consolidated. The sequestrum in such cases presents the following appearances:—the lower part is thick and annular, and includes the whole thickness of the bone. It is smooth externally, where it has been covered by the periosteum. About an inch or less above this it becomes thinner, is composed of the innermost part of the bone—that which surrounds the medullary canal—and it is roughened externally, where it has separated from the adjacent healthy bone; above this it is spiculated and very irregular, becoming gradually thinner (Fig. 28). The part of the bone which escapes necrosis is inflamed, and, as a consequence of osteo-plastic periostitis, new bone is deposited abundantly on its surface, leading to a great increase in its thickness, which can be recognised readily through the soft parts.

Conical or "Sugar-loaf" Stumps, as they are called, commonly form, either in consequence of the flaps having originally been cut too short, or from the bone not having been sawn off sufficiently high above the angle of the flaps: but in other cases they may occur, though the stump has been skilfully fashioned,

in consequence of the soft parts, which have been the seat of inflammation and suppuration before the amputation, retracting during the granulating process so as to denude the bone. In such cases as these, great retraction and contraction of the flaps are apt to go on during cicatrisation, so that the bone may never be covered at all, but be exposed at the bottom of an irritable ulcer; or, if the soft parts do coalesce, the cicatrix will be unable to support the slightest pressure without becoming ulcerated. In these circumstances, the only remedy consists in laying open the stump, and cutting off about three inches of the bone.

The patient, whose stump is represented in the accompanying figure (Fig. 29), was under the care of Christopher Heath in University College Hospital. The arm had been amputated in the bush in South Africa. The protruding bone was completely covered by a thin cicatrix.

Aneurismal Enlargement of the arteries of a stump is extremely rare. The only case of disease of the vessels with which I am acquainted is one described by Cadge, in which an aneurismal varix between the posterior tibial artery and veins formed in a stump after disarticulation of the ankle-joint (Fig. 30, *a*).

Fig. 30.—Aneurismal Varix in Stump.

Painful and Spasmodic Stumps.—The nerves in a stump naturally become somewhat expanded and bulbous; and no material inconvenience results from this condition. But it occasionally happens that a distinct tuberose enlargement forms in connection with one of them, and attains the size of a cherry or a walnut; and, this being pressed against the end of the bone, the stump becomes the seat of intense pain of a neuralgic character, more particularly whenever it is touched, when a sensation like an electric shock is felt. In such circumstances, excision of this bulbous extremity of the nerve, or resection of the stump so as to remove the end of the bone and the whole of the cicatrix, is necessary, and will effect a cure. Sometimes a nervous twig may become implicated in, and compressed by, the cicatrix. Here a more limited excision will remove the pain. Besides this form of painful stump, which may happen in the strongest and healthiest subjects, and is entirely dependent on local causes, there is another condition in which the stump becomes not only the seat of intense pain, but of continuous convulsive twitchings. This form of painful stump arises partly from constitutional causes, and most frequently occurs in females, more particularly in those who are of the hysterical temperament, and are or have been subject to neuralgic pains elsewhere. In these cases the general cutaneous sensibility of the stump is increased: it is the seat of convulsive jerkings or twitchings, and the pain is more or less intermittent, being increased under the influence of various emotional and constitutional causes. In such cases, the treatment should be conducted on the general

principles that will be fully discussed when we come to speak of neuralgia. No excision of the nerves of the stump, or even amputation higher up, is of any avail ; the disease, being constitutional, will certainly return in each successive stump, until at last the shoulder or the hip may be reached without any permanent benefit to the patient.

Occasionally after amputation a condition of chronic or subacute neuritis, with sclerosis of the nerve, is set up, which has a tendency slowly but steadily to extend upwards, involving new nerves as it goes, and finally, perhaps, leading to changes in the spinal cord itself. The symptoms and treatment are those of chronic neuritis, which will be fully described under Injuries of Nerves.

Recurrence of the Disease for which the Amputation was performed is not of uncommon occurrence in cases of strumous diseases of bones and in malignant tumours. In the former case, amputation higher up may be advantageously performed ; but in the latter, it is justifiable only when there is no evidence of secondary growths in internal organs or in the lymphatic glands.

Fatty Degeneration of the muscles of a limb, arising from their disuse, gives rise to a peculiar appearance in the stump. During the amputation, the muscles look like pieces of yellow wax, and are firm : no atrophy, so far as size is concerned, has taken place ; the fat being deposited between the muscular fibres, producing atrophy of them by its pressure and occupying their place, so that the general size of the limb and fulness of the stump are preserved. Union takes place in these circumstances, though somewhat slowly ; at least, this has occurred in several cases in which I have observed this condition. In one of these I amputated the leg for disease of the foot of nine years' standing, and in another the thigh for disease of the knee of fourteen years' standing.

MORTALITY AFTER AMPUTATION.

The general causes of death after operations have already been considered ; but we must now examine some special points connected with the relative mortality after amputations of different kinds, and the cause of the differences that exist.

Before commencing, however, it would be better in order, as far as possible, to avoid ambiguity, to mention and define the chief causes of death after amputation.

Shock is exhaustion of the nervous centres, the result of violent overstimulation by the powerful afferent impulse which arises from the injury done to the sensory nerves, either by the knife in amputation or by the injury which rendered the operation necessary. Death usually occurs, in fatal cases, under twenty-four hours.

Collapse is identical with very severe shock.

Secondary hæmorrhage, as a cause of death after amputations, is usually limited to those cases in which the bleeding occurs more than twenty-four hours after the operation.

Sloughing of the stump from amputating through injured or diseased tissues is an occasional cause of death.

Septic Diseases.—This term is here used to include all those affections which are connected, directly or indirectly, with decomposition of the discharges from the amputation wound, and the contamination of the air from the accumulation

of too many patients suffering from open wounds in too confined a space. The chief varieties are :—*Pyæmia*, a general disease, resulting from infection of the whole body from the unhealthy discharge of a foul wound, and accompanied by secondary inflammations, terminating in suppuration, in various internal organs and other parts of the body; *Septicæmia*, a similar condition, terminating fatally, without the occurrence of secondary local inflammations or abscesses ; *Septic Poisoning*, due to the absorption of the chemical products of putrefaction ; *Traumatic Fever*, which is a mild form of septic poisoning ; *Hospital Gangrene*, an acute spreading inflammation, terminating rapidly in death of the affected part ; *Erysipelas*, an infective inflammation of a specific nature, spreading widely from the wound and accompanied by grave constitutional disturbance. All these diseases are to be attributed directly to foul wounds and over-crowding.

The *Congestive pneumonia* often mentioned as a cause of death after amputations, is most probably always an effect of septicæmia, pyæmia, or septic poisoning.

Lastly, one of the commonest cause of death in Hospital reports is *Exhaustion.* This term is used with excessive looseness. Some Surgeons seem to employ it occasionally as even synonymous with shock or collapse. In the majority of cases, however, it really means that the patient is gradually worn out by the profuse discharge from a suppurating wound, combined with chronic poisoning by the absorption of the chemical products of putrefaction. In others it means that the patient died from the effects of severe traumatic fever, of septic origin, commencing on the second day, before he had fully recovered from the shock of the operation. It doubtless covers, therefore, many conditions which should fairly be included amongst septic diseases.

Shock is a frequent cause of death after primary amputations of the larger limbs ; but till quite recently pyæmia was the most frequent cause of death after all amputations, nearly one half of the patients that died perishing from this disease. Bryant, in 1859, has shown that, at Guy's Hospital, it was fatal in ten per cent. of all amputations, and in forty-two per cent. of fatal cases, and that it was most frequent after amputations through limbs, the tissues of which were in a normal condition, and where a large surface of healthy bone was exposed, as in amputations for injury, and in the removal of limbs for tumours, talipes, ankylosis, &c. It was not so common after amputations performed for chronic joint-disease.

The circumstances which more specially influence the general result of amputations, as well as the particular cause of death after the operation, may be divided into two classes :—*α.* Those that have reference to the general constitutional condition of the patient. *β.* Those that are connected with the operation itself.

α. To the first class may be referred 1, *Age* ; 2, *General Health* ; 3, *Shock* ; and 4, *Septic Diseases.*

1. **Age** exercises an important influence on the result of amputations. As a general rule it may be stated that, the younger the patient, the greater the likelihood of a successful result. At an early period of life there is a greater power of resisting the effects of poisoning by septic matter and of loss of blood. The feebler tissues of old people inflame and slough more readily than those of younger individuals, when exposed to the irritation of decomposing matter. The introduction of the antiseptic treatment of wounds has however,

greatly reduced the dangers of amputations after middle life. Volkmann of Halle has published the results of 48 cases of major amputations performed in patients above 50 years of age. He excludes from consideration all cases in which the amputation was performed during septicæmia, all double amputations, and some few cases in which the patient died of causes independent of the operation. Of the 48 only 2 died; 1 of tetanus, and 1, an habitual drunkard, 60 hours after the operation. The patient's ages were, 30 between 51 and 60, 13 between 61 and 70, 4 between 71 and 80, and 1 patient, aged 84, recovered from an amputation at the knee. Although the exclusion of all complicated cases makes these statistics more favourable than they would otherwise have been, the results must be looked upon as most encouraging, showing that under the improved treatment of wounds, we may hope for a fair degree of success even in very advanced life, provided that old age alone is the only unfavourable condition present.

2. The **General Health** of the patient previous to the operation exercises necessarily a most powerful influence on the chances of recovery. The state of the kidneys, more especially, is of great importance in this respect; for no condition tends more certainly to a fatal termination than a chronically diseased state of those organs. The results of amputation are also necessarily widely different, according as the operation is practised on the healthy inhabitant of a country district, or on the cachectic and debilitated denizen of a large town.

3 and 4. The influence of **Shock** and of **Septic Diseases** is very differently felt in different amputations. The greater the portion of body that is removed, the more severely is shock felt. In these cases, also, the influence of septic agencies becomes more marked. This is owing to two causes: 1. The depression of the nervous system consequent on the shock, and on the loss of blood that is the frequent accompaniment of a great operation, tending to lower the resisting power of the system to all noxious influences, and thus to predispose the patient to suffer, both locally and constitutionally, from the absorption of septic matter; and, 2. The large surface of wound exposed, rendering local contamination more likely to occur.

Out of 80 consecutive cases occurring at University College Hospital, there were 3 deaths from shock (all primary), and 10 from pyæmia and erysipelas; leaving only 8 deaths to be accounted for by exhaustion and the other causes that I have mentioned.

Out of a total of 631 amputations collected from the reports of some of the Metropolitan hospitals between 1866 and 1872, 239 deaths occurred, and of these 110 died from shock and pyæmia together, being 17·5 per cent. of the whole operated on, or 46 per cent. of the total deaths—and this is irrespective of those that are reported as dying of "exhaustion," or from "erysipelas," "low cellulitis," and forms of septic disease other than pyæmia. This terrible disease proved fatal in as nearly as possible 36 per cent. of all the deaths, and shock in about 10 per cent. of the deaths, or in 3·8 per cent. of all the amputations.

But the respective influences of these two great causes of death after amputations will be found not only to vary greatly, according as the operation is primary, secondary, or for disease, but also to exercise very different degrees of influence in different hospitals.

Shock was most felt in primary amputations, in the proportion of 25 per

cent. of the deaths; was but little fatal in secondary amputations, 6 per cent.; and was entirely absent as a cause of death in pathological amputations.

Pyæmia was the cause of death in about one-third, or 33 per cent., of the fatal cases amongst the primary amputations, and in 44·4 per cent. of the secondary; and in those for disease it again acquired nearly the level of the primary—viz. 34·6 per cent.

Pyæmia is proportionately more fatal after amputations of the upper than of the lower extremity, occasioning about 40 per cent. of the deaths in the former, against 34 per cent. of the latter, after amputations for all causes. In primary amputations the disparity is more marked, being about 50 per cent. of all deaths in the upper, against about 32 in the lower limb; shock, on the other hand, being more fatal by far after primary amputations of the lower than of the upper extremity, owing doubtless to the larger mass removed.

The influence of *shock* is necessarily most felt in primary amputations. Indeed, its fatal results are almost entirely confined to amputations performed within twenty-four hours of the infliction of the injury. Fatal shock, in fact, is the result of the combined depressing influence of the injury and of the operation. It occurs in exact proportion to the severity of the injury, the amount of loss of blood, and the age of the patient. It is often referable rather to the injury than to the operation; and it becomes a question whether, in many cases of serious and almost hopeless smash of a limb, it might not be better to let the patient expire in peace, than to subject him to the repetition of a shock which his nervous system will be utterly unable to endure. This is more especially the case in extensive crush and disorganisation of the lower extremity up to or above the middle of the thighs, such as are not unfrequent at the present day from railway accidents, in which the mangling of the limb resembles rather that produced by cannon-shot than by an ordinary injury of civil life. In these cases amputation through the upper third of the thigh, or at the hip-joint, is the only available operation. It is usually done in such cases. But is it ever successful in the full-grown adult? That is a question which deserves the serious consideration of hospital Surgeons. I am not acquainted with a single case in which such an operation has succeeded in general hospital practice, in men who have arrived at full maturity. In children and young adults it has proved successful. The three cases in which it was done, out of the eighty University College cases, all died of shock. The same catastrophe has happened in every other case on record with which I am acquainted. It is an operation that has been abandoned by military Surgeons in cases of compound comminuted fracture of the femur from bullet-wound in this situation; ought it not to be equally discontinued by civil Surgeons in those more hopeless cases of utter smash of the limb that occur in their practice? For my own part I shall never again, except in children and young people, amputate in that situation for such injuries—hopeless alike, whether left alone or subjected to the knife; surely it is better for the patient to be left to die in peace than to be again tortured by amputation, which all experience has shown to be useless.

It is of importance to observe, in reference to these cases of death from shock after primary amputations, that the fatal result happens in a few hours, usually within twenty-four, of the performance of the operation. Hence, although it may be disposed to by the previous condition of the patient, and the influence exercised upon his powers of endurance by the severity of the injury, the loss

of blood, his age, &c.—for death from shock necessarily occurs more frequently under similar conditions of injury at advanced than at early periods of life—or even by season of year, yet it cannot in any way be affected by the conditions to which the patient is exposed subsequently to the performance of the operation, so far at least as hospitals or other external influences are concerned. We must, therefore, look upon death from shock as a part of the general accident to which the patient has been exposed and of the injury that he has sustained, aggravated, doubtless, by the further depressing influence exercised by so serious an operation as an amputation possibly high up in one of the limbs. It is interesting to observe that season exercises an influence on the liability to death from shock after primary amputations. According to Hewson, of Philadelphia, it is most fatal in winter. The reason is obvious : the cold, to which the sufferer has been exposed after the accident, is an additional cause of depression.

If, therefore, we want to lessen the mortality consequent on these operations, the first point to look to is not to amputate needlessly in hopeless cases of smash of the thigh high up, in order to give "a last chance" to a patient whose vital powers have already been depressed to the lowest ebb by a fearful mutilation. Such amputations, which sometimes consist in little more than the severance of a limb still attached to the trunk by shreds of muscle, ought scarcely to find their way into a statistical table professing to give the results of operations the majority of which are more deliberately performed, and with a better prospect of success. They ought, in point of fact, to constitute a class of cases apart; the more so, as they are frequently complicated with internal injuries which are not detected until after the death of the patient.

Shock, as has already been shown, exercises its influence chiefly in primary amputations; far less in secondary ones; and disappears entirely, as a cause of death, in pathological amputations, except in a few cases of such operations as amputation at the hip-joint or shoulder-joint in patients already greatly enfeebled by disease. In amputation for disease "exhaustion" occupies the same prominent position as a cause of death that shock does in those for injury.

By far the most important of all the causes of death after operations in hospitals, is undoubtedly the development of *septic disease*. The importance of this is obvious, from a consideration of the following statistics. Out of the 21 deaths that occurred in 80 amputations at University College, no fewer than 10, or nearly one-half, arose from this cause; and, out of a grand total of 239 deaths occurring in four metropolitan hospitals, 86 died from pyæmia alone, without including other septic diseases and secondary septic visceral inflammations; there being nearly four times as many deaths from pyæmia as from shock.

The foregoing statements show that, if septic diseases could be absolutely prevented, no patient, who at the time of the operation was in good general health, should die of an amputation if he survive the period of shock, unless it be from tetanus or the weakness of extreme old age. Secondary hæmorrhage is almost as preventible as pyæmia by the exclusion of septic influences. The value of the majority of amputation-statistics is greatly impaired by all the cases being put together with no further separation than into primary and secondary, and we thus get a very false notion of the mortality occurring in ordinary cases. Some very valuable statistics have been published by Max Schede, in his work on Amputations, in which this source of error has been

eliminated. The cases are divided first into "Complicated" and "Uncomplicated." The Complicated cases, which are classed separately, are—Multiple or Double Amputations; cases complicated with other severe injuries; cases in which the patient was suffering from severe surgical fever, septicæmia, pyæmia, or tetanus, at the time of the operation; and, lastly, cases which terminated fatally, or in which the cure was incomplete after many months, on account of acute intercurrent diseases, such as delirium tremens, or acute pneumonia (not of septic origin), or chronic diseases, such as phthisis, Bright's disease, amyloid degeneration, secondary cancer, &c.

Secondly, the cases are divided into those treated antiseptically and those belonging to a period before the introduction of antiseptics and systematic drainage into the treatment of amputation wounds. The former are taken from the published statistics of Socin of Bâle, Volkmann of Halle, and Max Schede in Berlin; the latter from those of Bruns of Tübingen, Bardeleben of Greifswald, and Billroth, then of Zürich. The cases treated by the older methods showed the following results:—

	CASES.	DIED.	PER CENT.
Uncomplicated cases	377	110	29·18
Double amputations	10	3	30·00
Complicated by other injuries	5	4	80·00
" by Septicæmia, Tetanus, &c.	48	40	83·33
" by constitutional diseases	21	21	100·00
Total	461	178	38·83

By comparing these statistics with those given a little further on, it will be seen that they are not worse than the average statistics of amputations fifteen or sixteen years ago in this and other countries.

The cases treated antiseptically by carbolic acid dressings and all the precautions recommended by Lister, show the following results:—

	CASES.	DIED.	PER CENT.
Uncomplicated cases	321	14	4·4
Double amputations	13	3	23·8
Complicated by other injuries	11	8	72·72
" by Septicæmia, Pyæmia, Tetanus, &c.	45	30	66·66
" by constitutional diseases, &c.	27	16	59·26
Total	417	71	17·00

The causes of death in the uncomplicated cases are equally instructive.

CAUSE OF DEATH.	OLD TREATMENT. 377 Cases.	ANTISEPTIC TREATMENT. 321 Cases.
Pyæmia	72	0
Septicæmia	19	1
Erysipelas	2	1
Tetanus	0	1
Pyæmia simplex	6	1
Secondary hæmorrhage	3	1
Old age	2	1
Shock	6	8
Total	110	14

These figures need no comment. They prove that antiseptics are antagonistic to pyæmia, and the consequent value of a rigid antiseptic treatment in the circumstances in which the amputations tabulated by Schede were performed. But, truly, it is much to be regretted that it should be necessary to go to German sources to form an estimate of the value of the antiseptic treatment in amputations, and that we do not as yet possess any sufficient record of the practice of British Surgeons to guide us in this respect.

That the amputation-mortality in this country has materially diminished during the last twenty years is undoubted. The following table, published by Sir James Paget, proves this. In it is compared the amputation-mortality at St. Bartholomew's during two periods of four years each, at ten years' interval.

	Primary.			*Secondary.*			*For Disease.*		
	CASES.	DIED.	PER CENT.	CASES.	DIED.	PER CENT.	CASES.	DIED.	PER CENT.
1864—1868	51	14	27·4	37	17	45·9	142	45	31·6
1873—1877	37	8	21·4	11	2	18·0	172	22	12·7

At University College Hospital the amputation statistics for the last ten years give the results stated below. They have been dealt with on the same principle as those of Schede, but from want of sufficient detail it is not possible to separate them into those treated antiseptically and those treated by the older methods, or by modified forms of antiseptic dressing.

	CASES.	DIED.	PER CENT.
Uncomplicated Cases:—			
Primary	53	13	24·72
Secondary	18	3	16·66
For Disease	109	17	15·60
Complicated Cases:—			
Double Amputations			
Complicated with other fatal injuries	7	3	42·85
	2	2	100·00
Complicated by Septic Fever, Septicæmia, Pyæmia, or Tetanus at time of operation	29	14	48·27
Complicated by serious constitutional disease, as Phthisis, Secondary malignant tumours, Albuminoid deposit, &c.	14	8	57·14
Total	232	60	25·86

The causes of death in the uncomplicated cases were as follow:—Pyæmia, 13; septicæmia, 8; erysipelas, 1; shock and exhaustion, 8; secondary hæmorrhage and sloughing, 3. If the time over which the report extends is divided into two periods of five years each, it will be found that of the 13 cases of pyæmia, 10 occurred in the first, and 3 in the second, of these periods; 4 cases of septicæmia occurred in each. But although the mortality from pyæmia has thus lessened, the gross mortality from all causes remains unchanged, as may be seen by a reference to the tables published in former editions of this work. The amputation-mortality in my wards up to 1873, before antiseptics were used, had been 40·7 per cent. for injury—18·1 for disease—on an aggregate of 387 cases, being 25·8 per cent. for all cases, exactly the same as in the above table.

The improvement that has taken place generally in the amputation-mortality in this country cannot be attributed solely to the use of antiseptics, however

much they may have tended to it. It commenced before they were much used; and it is certain that Surgeons who do not employ the antiseptic treatment have obtained results that have never been surpassed by it. This they have achieved by a careful selection of cases, by improved methods of operating, by perfect drainage and rest, and great attention to cleanliness. The improved hygiene of modern hospitals also cannot be ignored as almost important factor in lessening the liability to the generation of septic diseases. Either hygiene is of no value in surgical cases, or some, and probably no inconsiderable share, of the improved results must in justice be assigned to the improved sanitary condition of modern hospitals. Spence of Edinburgh had once a run of 63 consecutive amputations with only 3 deaths; and Callender, by his mode of treatment, obtained results that it would be difficult to surpass. Amongst the most excellent results are those of Borland, of Kilmarnock, who out of 27 primary major amputations had 6 deaths, or 22 per cent., and in 63 secondary only 2 deaths, or 3·1 per cent. These successful results were obtained without antiseptics, by avoiding entirely the use of water during the operation, the blood being wiped away by pieces of clean rag, and by leaving the wound to glaze before bringing the flaps together, with perfect rest of the stump, which was dressed with a thin piece of rag smeared with lard, any discharge that formed being wiped away.

β. The circumstances connected with the amputation itself that influence materially its result are, 1—Its *Seat*. 2. The *Structure of the Bone* sawn. 3. Whether for *Injury* or *Disease*. 4. If for disease, the *Nature* of the affection. 5. If for injury, the *Time* that has elapsed before the operation.

1. With regard to the influence of the **Seat** of amputation on the result of the operation, it may be stated, as a general rule, that the risk is greater in proportion as the size of the part that is amputated increases, and as the line of amputation approaches the trunk; in fact, the nearer it is to the trunk, the greater is the danger. Thus the amputation of a toe or of the foot is less hazardous than that of the leg or the thigh. The subjoined table, derived from the examination of statistics of amputation in civil practice, collected from various British, Continental, and American sources, shows clearly the increase in the ratio of mortality as the operation approaches the trunk.*

SEAT.	CASES.	DEATHS.	PER CENT.
Shoulder-joint	117	58	49·5
Arm	1319	375	28·4
Fore-arm	1059	109	10·2
Hip-joint	46	19	41·3
Thigh	3477	1224	35·2
Leg	3006	985	32·7

If we turn to the statistics of military surgery, we find similar results. Thus, in the British army in the Crimea the percentages of death were, after amputation of the forearm, 7; of the upper arm, 19; of the shoulder-joint, 35; of the foot, 16; of the leg, 37; of the knee, 57; of the thigh, 64; and of the hip, 100. In the French army in the Crimea, the percentage of mortality

* The numbers referred to in this Chapter have been derived from the Tables published by Mr. James Lane in the last edition of Cooper's *Surgical Dictionary*; Sir J. Y. Simpson's paper on Hospitalism; various statistical papers in the Reports of Hospitals; M. Chenu's elaborate returns on the medical service of the French army in the Crimean War and in the Italian Campaign; and the official reports of the United States Army regarding the War of the Rebellion.

after amputation of the fore-arm was 45 ; of the arm, 55 ; of the shoulder-joint, 61 ; of the foot, 76 ; of the leg, 72 ; of the knee-joint, 91 ; of the thigh, 92 ; and of the hip, 100. In the Italian campaign of 1859, the percentages of the mortality in the French army—including in some cases operations on wounded Austrians—were : fore-arm, 42 ; arm, 56 ; shoulder-joint, 55 ; foot, 55 ; leg, 70 ; knee-joint, 75 ; thigh, 78 ; hip-joint, 57. In the war of the American rebellion the percentages of mortality were as follows, showing markedly how rapidly it runs up in accordance with the size of the part removed : fingers and hand, 1·6 ; wrist, 5·5 ; fore-arm, 16·5 ; arm, 21·2 ; shoulder, 39·2 ; partial of foot, 9·2 ; ankle-joint, 13·4 ; leg, 26 ; knee, 55 ; thigh, 64·4 ; hip, 85·7.

Not only is there this increase in the rate of mortality as the operation approaches the trunk, but in the larger limbs, more especially in the thigh, every additional inch that is removed appears to make a difference in this respect. Thus, in our army in the Crimea, of 178 amputations of the thigh, 44 were in the upper third, and of these 38, or 86 per cent., proved fatal ; 68 were in the middle third, and of these 41, or 60 per cent., died ; whilst in the lower third the mortality out of 66 cases was 37, or 56 per cent. In the French army in the Crimea, according to Chenu, of 81 amputations of the thigh at the upper third, 37, or 60 per cent., died ; in 91 amputations at the middle third, there were 63 deaths, or 69 per cent. ; and in the lower third there were 101 cases, with 59 deaths, or 58·4 per cent. In the Italian campaign of 1859, according to the same authority, there were 46 cases of amputation of the thigh at the upper third, with 43 deaths, or 93 per cent. ; 52 at the middle third, with a mortality of 44, or 84 per cent. ; and 43 at the lower third, with 36 deaths, or 83 per cent. Again, among 21 amputations of the humerus at the neck in the French army in the Crimea, the mortality was 9, or 43 per cent. ; in 229 at the upper third, it was 62, or 27 per cent. ; in 145 at the middle third, it was 27, or 18 per cent. ; and in 55 at the lower third, it was 6, or 11 per cent.

Not only do the size of the part removed, and its proximity to the trunk, materially affect the general mortality after amputation ; but these conditions also influence the particular cause of death. Thus after the smaller amputations, as of a toe, for instance, death occurs only in unhealthy states of the constitution, from the occurrence of erysipelas, or of some of the various forms of diffuse inflammation. Death after the larger amputations more frequently results from causes connected with the operation itself, as, for instance, secondary hæmorrhage, shock, or exhaustion by the abstraction of the large quantity of blood contained in the limb, as well as by that lost during the operation.

2. The **Part of the Bone** that is sawn through may influence the result. Amputations through the cancellous ends of long bones are less dangerous, in one respect, than those through their shafts, in consequence of the medullary canal not being opened when the section is made near the articular end : so that the liability in septic cases to diffuse suppuration of this cavity, and consecutive phlebitis and pyæmia, is diminished.

3. The mortality resulting from amputations is perhaps more directly influenced by whether the operation is done for **Injury or Disease**, than by any other cause, being far greater in corresponding limbs after injury than disease, except as regards amputation of the fore-arm. In the following table may be

seen the results of 307 consecutive cases of amputation performed at University College Hospital up to May, 1871. Of these 307 cases, 79 died, yielding as nearly as possible a mortality of 25 per cent.

RESULTS OF AMPUTATION IN UNIVERSITY COLLEGE HOSPITAL.

SEAT.	*Injury.*			*Disease.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh . . .	39	23	59·0	86	18	20·9
Leg and Foot . .	44	14	31·8	74	10	13·5
Shoulder and Arm .	12	5	41·6	24	8	33·3
Fore-arm . . .	8	0	0	20	1	5·0
Total . . .	103	42	40·7	204	37	18·1

Malgaigne's statistics from the Parisian hospitals illustrate this equally clearly, as will be seen in the following tables.

SEAT.	*Injury.*			*Disease.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh . . .	46	34	74·0	153	92	60·0
Leg	79	50	63·3	112	55	49·0
Foot	9	6	66·6	29	3	10·3
Arm	30	17	56·6	61	24	39·3

The following table gives the result of numerous cases in civil practice, collected from various sources. (See note, page 80.)

SEAT.	*Injury.*			*Disease.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh . . .	964	576	59·7	1465	477	32·5
Leg	771	356	46·1	1281	301	23·5
Arm	514	180	34·4	250	65	26·0
Fore-arm . . .	360	38	10·5	151	23	15·9

The *Shock* inflicted by the injury, with its subsequent evils, appears to be one of the principal reasons for the greater mortality after amputations for injury than after those for disease. After amputation for injury, also, there is a greater liability to the occurrence of gangrene of the stump, as the incisions may be carried through tissues which, though apparently sound, may be so bruised as to be beyond recovery. Pyæmia, formerly equally frequent in primary and secondary amputations, should now be equally rare. Exhaustion is more frequent after removal of a limb for disease, as in many cases the operation is necessarily performed on patients already weakened by long illness. In many forms of disease, however, especially in affections of bones and joints, it will be found that those patients do best in whom the disease is most chronic.

4. The **Nature of the Disease** for which the amputation is performed

influences its mortality. Thus amputations for malignant growths are more fatal than those for caries of bone or diseased joints. In cases of diseased joint, there is a greater tendency to recover when the affection is of a simple than when it is of a tuberculous nature. Birkett has pointed out that disease of internal organs, often of the same nature as that for which the operation is performed, is found after death in a large proportion of patients who die after amputation. When suppurative disorganisation of a joint is very acute, amputation, more particularly if the affected articulation be of large size, as the knee, is attended by very unfavourable results. In these cases the patient is usually suffering from severe febrile disturbance, the result of absorption of septic matter from the diseased joint, and amputation under such circumstances is frequently followed by fatal septicæmia. But when the disease has once become chronic, the precise period at which the amputation is performed exercises but little influence on the mortality, provided it be not deferred to too late a stage, when the patient's constitution is worn out by hectic.

Amputations of expediency—those performed for the convenience of the patient, as in cases of talipes or ankylosis, but not necessary so far as life is concerned—are especially fatal. Bryant has shown that, at Guy's Hospital, death has followed in 40 per cent. of these amputations in the lower extremity.

5. In amputation in cases of injury an important question has to be determined, viz., the influence exercised by the **Time** that has elapsed from the infliction of the injury to the performance of the amputation. Not only the rate of mortality, but the conditions that immediately occasion the fatal event, are influenced by the period at which the operation is performed.

Amputations for injury are commonly divided by Surgeons into *Primary* and *Secondary*; the *primary* being those that are performed during the first twenty-four or thirty hours, before any spreading inflammation or traumatic

RESULTS OF PRIMARY AND SECONDARY AMPUTATIONS IN CASES OF INJURY, AT UNIVERSITY COLLEGE HOSPITAL.

SEAT.	*Primary.*		*Secondary.*	
	CASES.	DEATHS.	CASES.	DEATHS.
Thigh	14	8	21	14
Leg and Foot . .	22	8	16	3
Shoulder and Arm .	6	2	5	2
Fore-arm . . .	6	0	1	0
Total . . .	48	18	43	19

fever has developed itself. By *secondary* amputations, many Surgeons mean those operations that are practised after the first twenty-four hours; whilst others again more correctly restrict the term to those that are done after suppuration has been fully established, when the surgical fever is beginning to subside as granulation-tissue springs up to present a barrier to the absorption by the lymphatics of the septic poison. Those who thus limit the use of the term *secondary*, call all the operations performed between the end of the first day and the period of full suppuration "intermediate." The distinction is of some importance, as operations performed during high surgical fever are extremely fatal. In the following table, the cases are divided merely into

primary and secondary. The cases have been collected from various sources, and the table shows the relative results of primary and secondary operations in civil practice.

SEAT.	*Primary.*			*Secondary.*		
	CASES.	DEATHS.	PER CENT.	CASES.	DEATHS.	PER CENT.
Thigh	235	153	65·1	156	85	54·4
Leg	405	178	43·9	150	72	48·0
Arm	276	79	28·6	75	32	42·0
Fore-arm	190	16	8·4	27	6	22·2
Total	1106	426	38·5	408	195	47·7*

While the percentage of deaths after primary amputation of the thigh exceeds that after secondary amputation, the rate of mortality in amputations of the leg, fore-arm, and arm is greater after the secondary than after the primary operation, especially in the upper limb. Primary amputation of the thigh is, indeed, one of the most fatal operations in Surgery. Thus of 46 cases of primary amputation recorded by Malgaigne, 34 perished; of 18 cases in the Massachusetts Hospital at Boston during the five years 1863—1868, 15 died; 9 cases out of ten died at the London Hospital during the years 1863—1866; and of 24 cases recorded by South, Lawrie, and Peacock, as occurring at St. Thomas's Hospital, the Glasgow Infirmary, and the Edinburgh Infirmary, every one perished. The danger of amputation of the thigh for injury is increased in proportion to the height at which the limb is severed. It is least in those cases where the operation is done for injury of the leg or knee-joint, and greatest when it is performed for compound fracture of the femur, recovery being then very rare. This excess of mortality after primary amputation of the thigh must be referred mainly to the intensity of the shock, whether produced by the operation itself, or, as is more often the case, by the injury which has rendered its performance necessary.

In primary amputations of the leg, arm, and fore-arm, however, the influence of this cause is relatively less, while in secondary amputations of these parts, as well as of the thigh, shock is much less intense. In these, the danger arises from pyæmia, gangrene, diffuse inflammation, secondary hæmorrhage, and all those morbid conditions that are favoured by defective hygienic circumstances, and which appear to exercise a more uniformly unfavourable influence over the secondary amputations than shock does over the primary.

In military practice, secondary amputation is, in general, more fatal than primary. Thus, Faure saved only 30 out of 300 secondary amputations, whilst Larrey saved three-fourths of those in which he amputated primarily. In the Peninsular war, the mortality after secondary amputation of the upper extremity was twelve times, and after secondary amputation of the lower limb, three times, as great as after primary amputation of these parts. In the British army in the Crimea, from the 1st of April to the close of the war, the relative rates of mortality per cent. after primary and secondary amputations were as follow:—after *primary* amputations at the shoulder, 26; of the arm, 17; of the fore-arm, 3; of the thigh, 62; of the leg, 30; and of the

* The reader who wishes to pursue this subject further will find a very large body of statistics on the results of amputations in the last edition of Cooper's *Surgical Dictionary*.

foot, 17 ; after *secondary* amputations at the shoulder, 66 ; of the arm, 31 ; of the fore-arm, 28 ; of the thigh, 80 ; and of the leg, 76. Or, for the upper extremity, the whole rate of deaths after primary was 15, against 41 after secondary amputations ; whilst, for the lower extremity, excluding the foot, it was 46 per cent. for the primary, against 78 for the secondary.

In the American army during the war of the rebellion, the mortality after primary amputation of the thigh was 54·13 per cent. ; and after secondary amputation, 74·76. In the French army in the Crimea, on the other hand, the mortality after primary amputation of the thigh and arm—amounting in the former limb to above 90 per cent.—was greater than that after the secondary operation.

As has already been observed, not only does the *rate* of mortality differ in primary and secondary amputations, but also the *cause* of death. Primary amputations are most frequently fatal from shock, hæmorrhage, and exhaustion, although death from pyæmia and septicæmia is by no means rare in these cases. Secondary amputations for injury most commonly carry off the patient by the supervention of septic diseases. Amongst the secondary affections that are of most frequent occurrence, gangrene of the stump stands in the first place, especially after amputation of the thigh for injury, and more particularly if the limb have been in a similar condition before the amputation. Then, again, erysipelas, phlebitis with pyæmia, secondary hæmorrhage, and some of the low forms of visceral inflammation or congestion, as pneumonia, pleurisy, and diarrhœa—all probably due to septic poisoning—often produce death. Pyæmia, complicated by congestive and suppurative pneumonia, is the most frequent cause of death after secondary amputation of the leg and arm. Secondary hæmorrhage to such an extent as to prove fatal is of very rare occurrence.

Summary.—On reviewing the whole subject of the causes of death after amputations, we cannot but come to the conclusion that the mortality is influenced more directly and distinctly than that of any other operation, except perhaps ovariotomy, by the hygienic conditions to which the patient is subjected after the operation. The evil influences arising from exposure to an atmosphere vitiated by the emanations from the decomposing discharges from suppurating wounds, and to those various combinations of conditions that are summed up under the one general term "*Hospitalism*," exercise so important a bearing upon the death-rate after amputation, that, in order to arrive at a just estimate of the probable chances of recovery in any given case, it becomes necessary not only to consider whether the operation be done for injury or disease—whether it be primary or secondary—whether the disease be simple or malignant—whether the patient be aged or young, healthy or diseased ; but, above all, whether, after the removal of the limb, the patient will be exposed to those conditions that result from the aggregation of the sick and the crowding together of foul suppurating wounds.

Whatever explanation we may give of the fact, it remains certain and incontrovertible that the rate of mortality after amputation of all limbs in the large city hospitals of Great Britain up to a very recent period has been at least 1 in 3 (*vide* Table). In those of Paris, out of 1,656 amputations, the statistics of which were collected by Malgaigne and Trélat (Simpson), 803 died, or nearly 1 in 2 (*vide* also Table). The Government statistics collected by Bristowe and Holmes show that in 1861 the amputation death-rate in

Parisian hospitals was 3 in 5, and more recently Le Fort gives the mortality at 58 per cent. In Germany matters were not much better. Billroth's published amputation-mortality has been from 43 to 46 per cent. In the United States the death-rate is much smaller, however; the mortality in the Pennsylvania Hospital being only about 24 per cent., and that of the Massachusetts General Hospital 26 per cent.

In military practice, the result of the experience deduced from the mortality following amputations during the great modern wars is at least equally unfavourable. But here there are so many modifying and disturbing elements, that it may be well to exclude these cases from consideration.

In fact, then, on taking the average mortality after amputation of all four limbs in the largest hospitals in the great centres of civilisation, we come to this result, that it commonly varied from 60 to 35 per cent., and did not fall below 24 per cent.: and that in certain of the larger amputations, as in the upper third of the thigh and at the hip-joint, it ran up to from 70 to 90 per cent. Widely extended statistical returns have shown but too plainly that these figures are trustworthy and constant, when founded on sufficient numbers and carried over a sufficient length of time to eliminate the influence of accidental circumstances operating for or against the patient.

So constantly did these figures come out in hospital returns, that Surgeons had almost come to regard them as representing the necessary, or, so to speak, the *natural* rate of mortality after amputations. But is this so in reality? Is this frightful rate of mortality the necessary result of the operation, and thus beyond our control? or is it dependent on causes that are preventable, and that may in great part, if not wholly, be removed? That it is not necessary—that it is dependent on preventable causes and will eventually be more materially diminished is evident from the admirable results that have of late years been obtained by Callender, Lister, Spence, and others, by different methods of treatment, but all having in view attention to the hygienic conditions of the wound and of the patient.

The statistics, quoted in a former page from Max Schede's work on amputations, show what can be accomplished by the antiseptic treatment. The system adopted by the Surgeons, from whose practice those statistics were collected, was that recommended by Lister. It matters little, however, what method of dressing is adopted, so long as the decomposition of the discharges is absolutely prevented. This is the principle of antiseptic surgery; but the best means of carrying it out has probably yet to be discovered. Whenever antiseptic treatment is efficiently carried out, by whatever means it may be accomplished, the wound ceases to be a source of infection and of contamination to the surrounding atmosphere, and the results of hospital practice may then equal the best that can be obtained in private.

Up to 1869 Surgeons had no opportunity of obtaining a knowledge of the results of amputations on a large scale, except such as had been furnished by the statistical reports of hospitals; but in that year Sir James Simpson collected from small country hospitals, and from private practice in manufacturing and mining districts, in which amputations are of common occurrence, statistics which proved satisfactorily that in the time before the modern improved methods of treating wounds were fully understood, the aggregation in one building of patients suffering from open wounds exerted a powerful influence on the proportion of deaths.

Simpson collected the particulars of 2,098 amputations of all kinds occurring in the country and in private practice in towns; of these 229 died, or 1 in 9·2; whilst of an almost equal number, viz., 2,089 amputations, performed in the large city hospitals of Great Britain, 855 died, or 1 in 2·4.

It is quite possible that Simpson's figures were not absolutely but only approximately correct, and that certain sources of fallacy had intruded themselves, more especially with regard to the condition of the patient *before* the operation, to which undoubtedly great importance must be attached (*vide* p. 75). But still, making full allowance for all this, the difference is so great between the two sets of cases, that the general result, viz., that the mortality after amputation in hospital practice was nearly four times as great as when the same operations were performed out of hospital, cannot be very materially affected; and it was impossible to escape from the conclusion that the high hospital-mortality was greatly influenced by the exposure of the patient to those septic conditions existing in the air of large hospitals, which have been so ably and graphically described by Parkes, and which exercise the most injurious effect on patients with large wounds who are exposed to them.

That those septic influences may eventually saturate hospitals, and exercise a most important influence in causing fatal pyæmia, septicæmia, and osteomyelitis, after amputations, from which, as has already been shown, a large proportion of those operated on formerly died, is evident from the following considerations.

1. From the commencement of this century up to a comparatively recent period—during what, in fact, may be termed the pre-sanitary age—no improvement had taken place in amputation-mortality in hospitals.

2. The prevailing high rate of mortality varied greatly in different hospitals in the same town, in which the patients were of the same class of society, followed pretty much the same occupations, and were subjected to the same kinds of injuries and diseases; the hospitals being officered by Surgeons of equal professional skill, and the only inequality existing being in the different sanitary conditions to which the patients were exposed in different hospitals.

3. The difference in the amputation-mortality in different London hospitals varied from 18 and 25 to 47 per cent. In Calcutta, the death-rate after thigh amputations varied in different hospitals from 42 to 80 per cent. (Downie).

4. Of late years, this excessive amputation-mortality has been materially reduced in most hospitals.

5. This reduction is contemporaneous with, and, *as all the other conditions continue as before*, must be dependent upon, the greater attention paid to hospital hygiene and the employment of antiseptics, in the treatment of wounds.

6. In military practice, the rate of mortality after amputation has been found to be in the direct ratio of the aggregation of the wounded; and infective processes of septic origin may almost, if not entirely, be averted by isolation of the patients.

CHAPTER III.

SPECIAL AMPUTATIONS.

There are, as has already been stated at pp. 54—64, three distinct methods of amputating limbs, viz., the flap, the circular, and the oval. The choice of the method influences the shape, and to a certain degree, perhaps, the utility of the resulting stump. But it in no way affects the safety of the patient, which is dependent on far different and far more important conditions than the manner in which the Surgeon shapes his incisions for the removal of the diseased or injured limb (p. 49). A skilful Surgeon will be able to produce a satisfactory stump by any one of the three methods, and it is desirable that he should be able to practise all. For although, as a general rule, one method may be more applicable than another, yet exceptional cases occur at times in which it may be advantageous to depart from the method usually adopted, and employ one of the others. In fact, a Surgeon should be eclectic in his method of amputating, and select that which is most suitable to the circumstances of the case before him. The flap-method or the combined flap and circular, is that to which most Surgeons give the preference in this country.

In describing this or any other method of amputating, precise rules may be laid down for its performance through sound structures. But it often happens, especially in cases of injury, that the destruction of tissue is so irregular as to compel the Surgeon to depart from definite rules of practice, and to shape his flap as best he may from the uninjured soft parts. There he must rely on his own judgment. But so efficient is the moulding process of nature, that provided sufficient integumental covering be left on the muscles and bones, a stump that at first looks very irregular and perhaps somewhat unsurgical, will in a short space of time acquire a regular outline and smooth surface, and may be eventually in all respects as useful as one that may from the first have been fashioned more artistically.

Amputations of the Hand.—The **Fingers** often require amputation for injury or disease, more especially the result of bad whitlow. In many cases the ungual phalanx becomes necrosed, and may usually most readily be removed without amputation, by making an incision through the pulp of the finger and then extracting the diseased bone, thus saving the nail and pulp, which will form an excellent end to the finger; and, if the operation be done in early childhood, a new and movable phalanx may form. Should amputation be required, it may be done by either cutting into the joint from its dorsal aspect with a narrow-bladed bistoury, and making the flap from the palmar aspect by cutting from within outwards: or the flap may conveniently be made from the palmar surface by transfixion, and the joint then cut across (Fig. 32). In amputating the ungual phalanx from the dorsal aspect, the Surgeon must stand facing the hand; the finger must be flexed forcibly, so that the last phalanx is at a right angle to the next. The incision to open the joint must

be made in continuation of an imaginary line drawn along the side of the second phalanx, midway between the dorsal and palmar aspects. It must

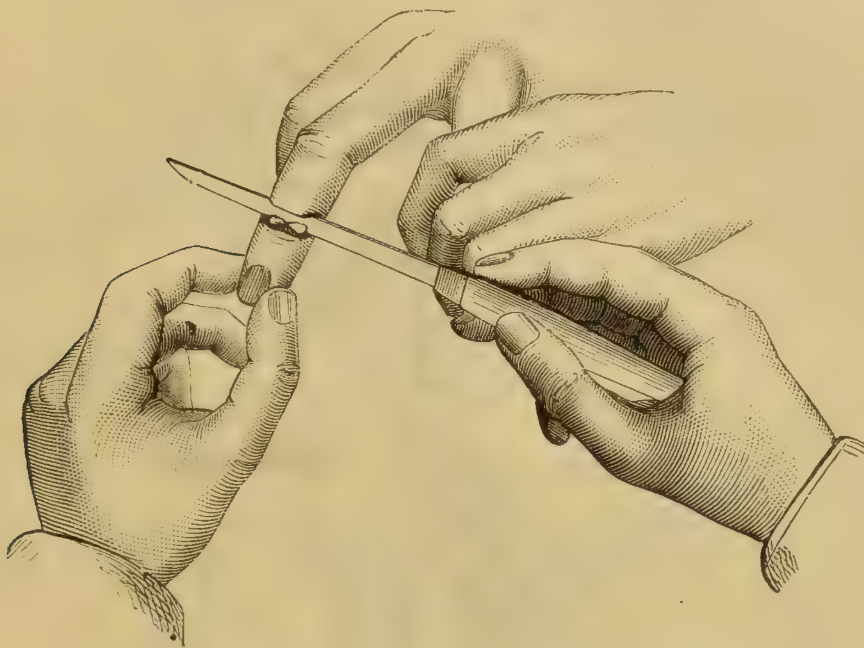


Fig. 31.—Amputation of Part of a Finger by Cutting from Above.

commence at the crease opposite the joint, and finish at the corresponding point on the other side, the Surgeon cutting from his left to his right side of the finger. As the joint opens, the lateral ligaments must be touched with

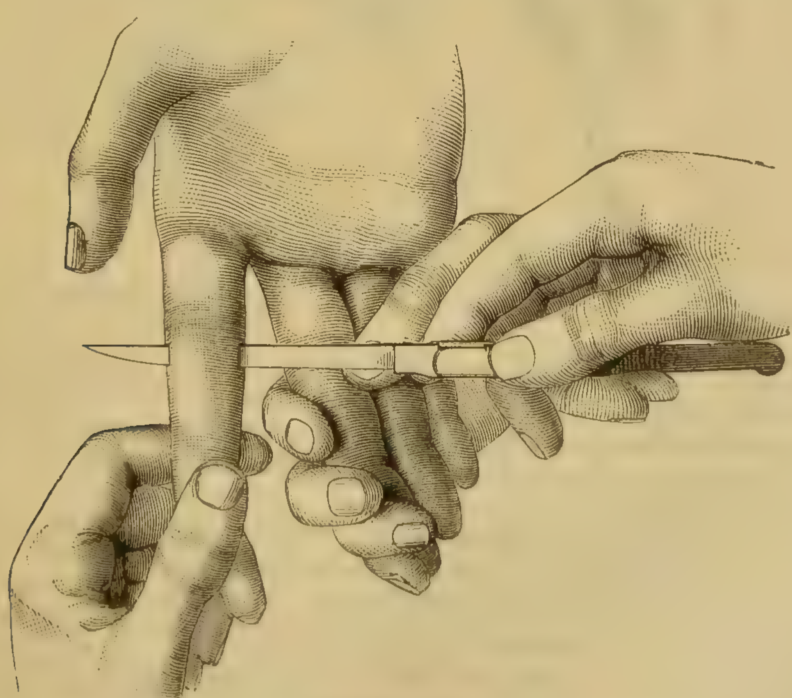


Fig. 32.—Amputation of a Finger. Cutting the Flap by Transfixion.

the point of the knife. As these are divided, the first two phalanges must be extended while the ungual phalanx is still further flexed. The knife is then to be passed with a sawing motion towards the palmar surface of the phalanx,

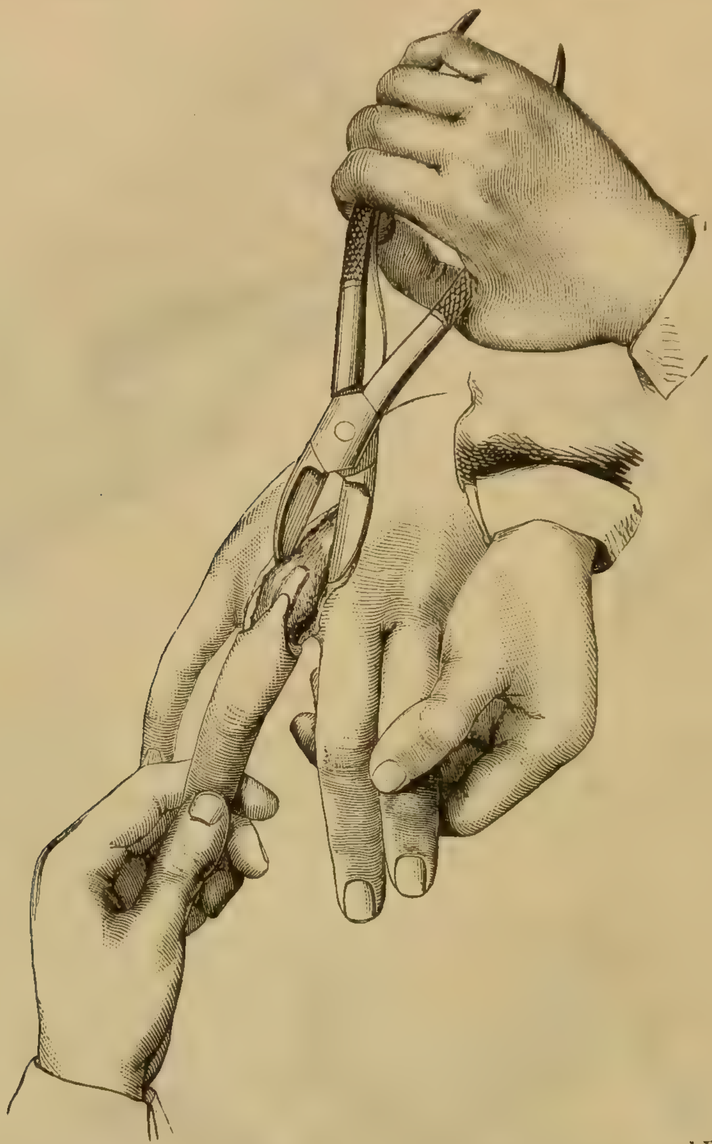


Fig. 33.—Amputation of a Finger. Removing the Head of the Metacarpal Bone.

the edge being turned slightly towards the bone. Finally, the ungual phalanx is to be fully extended, and a flap cut including the whole pulp (Fig. 31). When any difficulty is experienced in finding the joint, it is either from taking a wrong line, or from the presence of a small rheumatic exostosis on the base of the ungual phalanx.

In amputating by transfixion from the palmar surface, the finger must be extended with the palmar surface towards the Surgeon. The knife must be made to transfix the finger as close to the bone as possible, and in such a way that its back is one-eighth inch on the distal side of the crease corresponding to the joint. A flap of sufficient length is then cut, which must be raised and held out of the way by an assistant. The joint is then opened, the operator bending the last phalanx forcibly backwards to put the anterior

ligament on the stretch. Finally, the phalanx is removed by carrying the knife through the joint, no flap being made from the dorsal aspect (Fig. 32).* In doing this, care must be taken to avoid cutting too high up, and so mistaking the depression above the head of the second phalanx for the articulation.

Amputation is performed between the proximal and second phalanges in the same way ; but as a stump composed of the first phalanx is of but little use, it is more common to remove the whole finger. In the hand of a working man, however, it is perhaps better to save even one phalanx, as it helps somewhat to strengthen the grasp ; for the stump can be strongly flexed, partly by the action of the interossei and partly by the long flexors which form new attachments at its extremity. In the case of the index finger, it will be better always to leave the proximal phalanx, the stump of which forms a useful opponent to the thumb.

Amputation is frequently required at the **Metacarpo-phalangeal Articu-**

Fig. 34.—Amputation of the Index Finger. Removing the Head of the Metacarpal Bone.

lation. Here it may be done in two ways : either by lateral flaps, or by the oval method. If by *lateral flaps*, the adjoining fingers should be well separated from the one about to be removed, by an assistant who grasps the hand, so as to put the integument on the dorsum upon the stretch. The point of a bistoury is entered immediately above the head of the metacarpal bone, carried forwards to a point opposite the interdigital web, drawn across the side of the finger, and then carried a little way into the palm. This same

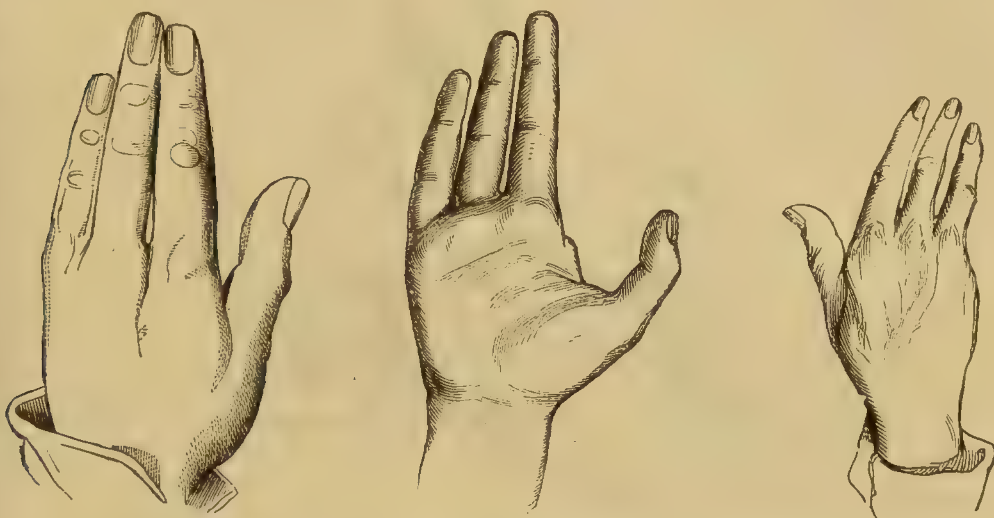
* For the Conservative Surgery of the Hand, *vide* chapter xlvii.

process is performed upon the opposite side, the flaps are dissected down by a few touches of the knife, the extensor tendon is divided, the joint opened, and disarticulation performed. The *oval method*, which I think is the best, as it does not wound the palm, consists in entering the bistoury at the same point as in the last case, carrying it as far as the point at which the web joins the finger which is being taken off, on the operator's right hand side ; then across the palmar aspect, in the line of the fold in the skin at the root of the finger, to the web on the other side. Thus far the incision may be made without taking the knife out of the wound. The oval is completed by putting the point of the knife in the end of the first incision and carrying it upwards to the starting point, the Surgeon's hand and the handle of the knife, during this second part of the operation, being over the back of the patient's hand. The two sides of the oval should be exactly symmetrical, and the incisions from the starting point to the web should not be straight, but slightly curved in such a way that their convexities look towards the middle line of the finger which is being removed. By a few touches of the knife the oval flap is turned back ; the flexor tendon is then divided and the articulation opened from the operator's right hand side ; finally the finger is removed by twisting it round, while the edge of the knife is pressed against the base of the first phalanx with a slight sawing movement. As a general rule, it is better to remove the head of the metacarpal bone, together with the finger ; otherwise a wide gap will be left in the situation of the finger that has been amputated, and much deformity of the hand will result. In order to do this the incision must be commenced on the dorsum about three-quarters of an inch above the head of the metacarpal bone, and be carried straight downwards to a point opposite the head, where an oval incision, similar to that above described, is commenced. We thus get what is known as a "racket-shaped incision." In removing the middle and ring fingers, it will be found more convenient to take out the head of the metacarpal bone after disarticulation. This is done by cleaning the dorsal surface and sides, taking care to keep close to the bone, and not to let the point of the knife plunge into the palm, so as to wound a digital branch at a point where it could with difficulty be secured. The bone-forceps are then applied, in a transverse direction, immediately above the head of the bone (Fig. 33). The operator then places the tip of his fore finger in the palm of the hand, so as to push the separated head slightly out of the wound, while, at the same time, he drags it downwards with his thumb placed on the cut surface of the bone. By a few touches of the point of the knife it is easily turned out, and by the slightest care all risk of wounding a digital branch is avoided. If it be the index finger, the bone should be cut obliquely, so as to shape it to the tapering form of the hand (Fig. 34). This may be done either with the bone-forceps or with a small saw. The saw has the advantage of making a smoother section and of leaving no splinters. If it be cut directly across, an ugly and inconvenient square protuberance, liable to constant injury, will be left. When, however, the patient's employment is one in which great strength and breadth of hand are required, and where appearance is of little consequence, the head of the bone may advantageously remain.

In amputating the little finger, with the head of the metacarpal bone, the incision must be commenced at the inner side of the hand, at a point corresponding to the middle of the shaft of the bone, and carried straight downwards to a point opposite the head, from which the oval must be begun.

The flaps so formed are most conveniently held out of the way by an assistant with a pair of blunt hooks during the division of the bone. This must be sawn obliquely, as in the case of the index finger. As in the index finger, the head may be left in the hand of a working man.

The after-treatment of these cases is extremely simple. The hand should be put upon a splint, the wound covered with some simple dressing, and the ends of the fingers, with small pieces of lint interposed, tied together by means of a tape, care being taken, however, that they do not overlap. The shaft of the



Figs. 35, 36, 37.—Results of Amputation above Metacarpo-Phalangeal Articulation in Middle, Index, and Ring Fingers.

metacarpal bone that is left will gradually atrophy, and thus a very taper and shapely hand will eventually be left (Figs. 35, 36, 37).

In disease or injury of the **Thumb** as little as possible should be removed by amputation ; for, if even but a very short stump of the metacarpal bone be left, it will serve as an useful opponent for the other fingers.

Amputation of the Thumb with its Metacarpal Bone is an operation which can very rarely be required. In cases of injury the surgeon must use all his ingenuity to save even the smallest part of the bone, or if any doubt exists as to how much can be saved, the hand should be dressed antiseptically and left to nature, a stump being fashioned later on, after the dead parts have separated. By this means more can be saved in many cases than at first seemed possible. In cases of disease of the metacarpal bone, excision of the bone should be preferred to complete amputation. Should the operation, however, be necessary, it may be done either by the flap or the oval method. The flap method is thus performed : The Surgeon stands with the back of the patient's hand towards himself, the limb being midway between pronation and supination, and he holds the thumb by the ungual phalanx. In operating on the *right* side he commences the incision immediately above, and a little to the palmar aspect of the tubercle to be felt at the outer side of the base of the metacarpal bone ; from this point he carries a curved incision passing immediately below the metacarpo-phalangeal articulation on the dorsal aspect to the middle of the web between the thumb and index finger. While making this incision, the operator's hands are necessarily crossed, but this causes no inconvenience if he leans slightly over the patient's hand. Still holding the thumb, the

operator now supinates the hand, and passes the knife by transfixion from the lower end of the first incision, in the web, to the point at which it was com-

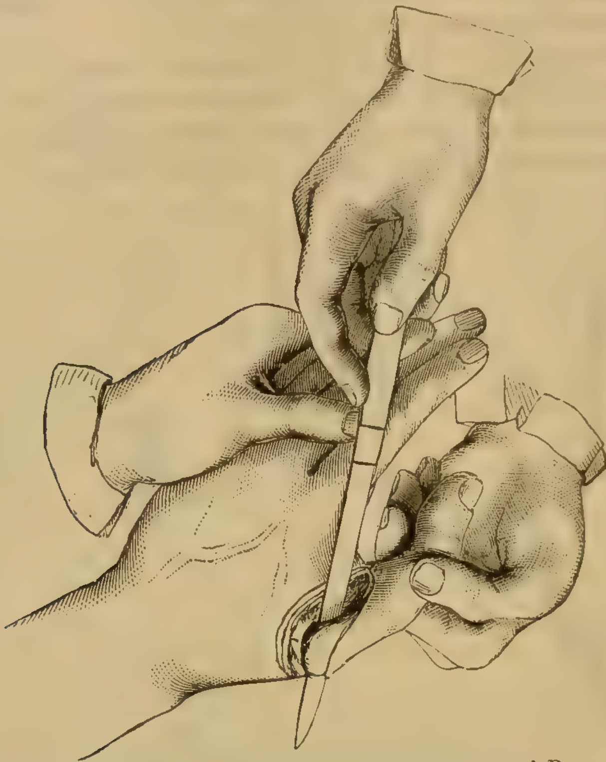


Fig. 38.—Amputation of Left Thumb and Metacarpal Bone.

menced, taking care to keep the blade close to the palmar aspect of the metacarpal bone. The palmar flap is now cut, the knife being brought out in a

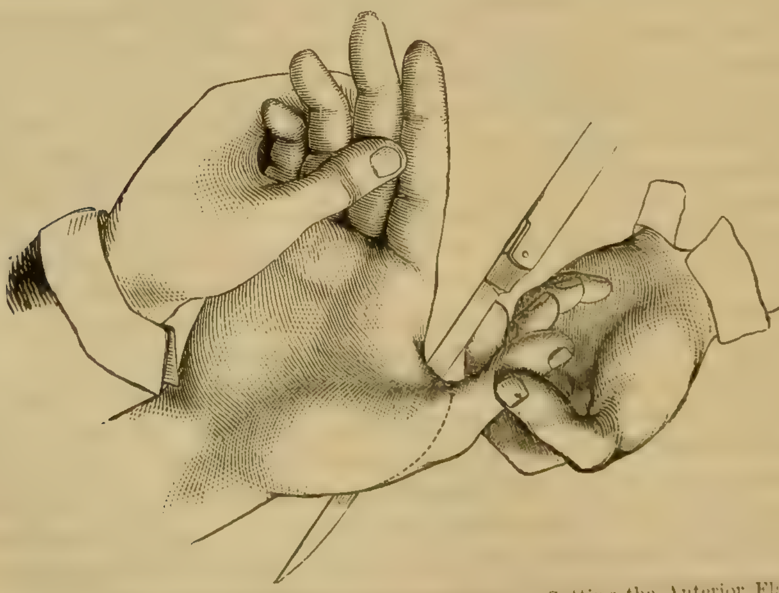


Fig. 39.—Amputation of Right Thumb by Transfixion. Cutting the Anterior Flap.

line exactly corresponding to the incision which has been made on the dorsal aspect. During this part of the operation the thumb must be slightly

adducted, and care must be taken not to haggle over the sesamoid bones, and at the same time not to notch the flap by turning the edge of the knife too much towards the palm in trying to avoid them. The palmar flap being cut, the Surgeon hands the thumb to an assistant while he dissects back the dorsal flap by a few touches of the knife. This being accomplished, he again takes the thumb, and forcibly abducts it, while he carefully passes the knife down towards the joint, along the palmar aspect of the metacarpal bone, separating the remaining attachments of the short muscles, and finally opening the articulation from its inner and palmar aspect. During this part of the operation the knife must be kept turned towards the bone, so as to avoid wounding the radial artery as it passes between the heads of the first dorsal interosseous muscle. As soon as the joint is opened, the thumb should be separated by twisting it round while the edge of the knife is sawed gently against the base of the bone. The radial artery, as it winds below the styloid process, is easily wounded at this stage of the operation, unless the knife is kept constantly in contact with the bone. In operating on the *left* side, exactly the same course is followed, except that it is not necessary for the Surgeon to cross his hands, and the first incision is made from the web to the base of the bone, and the transfixion from that point to the web.

Fig. 40.–Result of Amputation of Thumb.

In the oval method of amputating, which is, as a rule, to be preferred, the incision is commenced opposite the outer tubercle at the base of the metacarpal bone, and carried along the outer border of the bone to within about half-an-inch of the head. From this point an oval incision is carried round, passing in front over the metacarpo-phalangeal articulation, thus completing a racket-shaped incision. The flaps are then turned back, care being taken not to open the metacarpo-phalangeal articulation, and the operation is concluded in the same way as in the transfixion-method. Should the metacarpo-phalangeal articulation be opened, the phalanges must be removed, and the head of the metacarpal bone seized in a pair of lion-forceps, after which no difficulty will be found in finishing the operation. Fig. 40 shows the hand after amputation of the thumb.

The **Metacarpal Bones**, with or without the fingers supported by them, occasionally require removal for disease or injury. For these operations, which are not of a very regular kind, it is difficult to lay down definite rules; in performing them, care should be taken to make good flaps of sufficient size, but to avoid cutting into the palm if possible. It is well not to disarticulate the lower ends of the bones, so as to open the wrist-joint, but rather to cut them off with bone-forceps or a metacarpal saw a little above this. In injuries from the explosion of powder-flasks or gun-barrels, when the hand is much shattered, it is of great consequence to avoid cutting up the palm to too great an extent; and it is well in these cases to save a finger if possible, which will be of more use to the patient than any artificial limb, however ingeniously constructed (Figs. 41 and 42). When only one finger is left, as the index or little finger, with the thumb, in cases of partial amputation of the hand after injury or for disease, the digit that remains not only becomes more mobile than formerly,

but greatly increased in size and much stronger, so that its utility is materially augmented. In all cases in which the extent of the injury is doubtful, the hand may be rendered thoroughly aseptic by immersion in a bath of carbolic acid lotion (1 to 20) for a few minutes, and then dressed with some antiseptic dressing for a week or more, and a secondary amputation performed when the limits of the injury are clearly defined. If the prevention of decomposition is successfully accomplished, no constitutional or local trouble is caused by this mode of treatment, and the amount saved is often more than was at first expected.

Fig. 41.—Hand after Amputation of Metacarpal Bones and First Two Fingers.

Fig. 42.—Hand after removal of Metacarpal Bones and Three Fingers, leaving Thumb and little Finger.

The mortality after amputation of the fingers and metacarpal bones is very trifling. Should death unfortunately occur after such a slight operation, it would probably be by the accidental occurrence of some general disease, such as erysipelas, pyæmia, or tetanus, to which every wound renders a patient liable.

An excellent stump may in some cases be obtained by amputating between the carpus and metacarpus. All the movements of the wrist-joint remaining perfect, a very useful artificial hand can be easily applied.

Amputation at the Wrist is not very often required. In performing disarticulation at this joint, its peculiar shape, with the convexity looking upwards, must be borne in mind. The operation may be performed in two ways, the chief flap being cut either from the dorsal or palmar surface. In the first case, it is best performed by *Teale's method* (Fig. 43). A perfectly square flap, whose four sides are each equal in length to half the circumference of the limb at the level of the wrist-joint, is raised from the back of the hand.

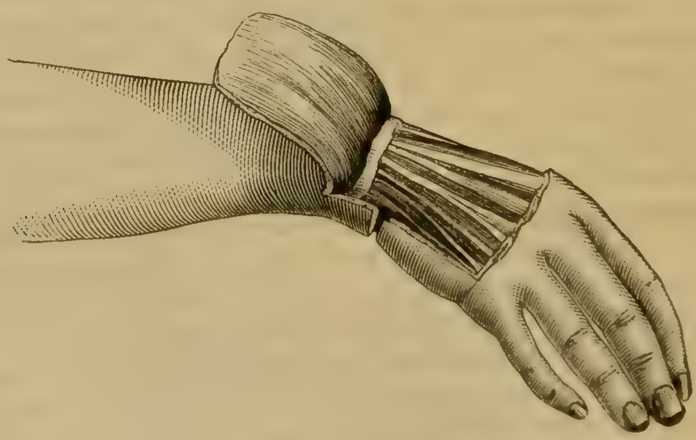


Fig. 43.—Amputation of the Wrist by Teale's Method.

It must consist of skin and fat only, the extensor tendons being left on the hand. A short palmar flap, also composed of skin and fat only, and equal in length to one-quarter of the dorsal flap, is now raised. The extensor tendons may now be divided at the level of the wrist, and the joint opened and disarticulated. Lastly, both flaps being held well back, the flexor tendons are smoothly divided with a single sweep of the knife. The flaps must be brought accurately together in the way described on p. 63, Fig. 25. By this method the dorsal flap is somewhat long and thin, and is consequently liable to slough unless it be very carefully raised, care being taken not to turn the edge of the knife to the flap, but to keep it constantly directed towards the parts to be removed.

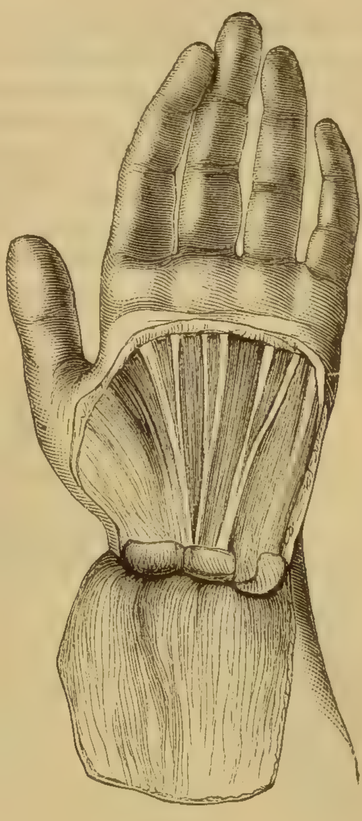


Fig. 44.—Amputation at the Wrist by Long Palmar Flap.

In amputation by the *long palmar flap*, the operation has been performed, either by cutting the flap from within outwards after opening the wrist-joint, or by shaping the flap from the palm first and disarticulating afterwards. The former method is objectionable, as the prominence of the pisiform bone and the hook of the unciform on the inner side render its performance extremely difficult. In the latter method (Fig. 44) a large flap, almost square in shape, but having its angles rounded off, is marked out in the palm by an incision, commencing at one styloid process and terminating at the other. The flap should extend as far as to within one finger's breadth of the transverse fold in the palm opposite the heads of the metacarpal bones. The flap having been thus marked out, is carefully raised from the palm, and is made to include everything down to the flexor tendons. This is done without difficulty till the ridge of the trapezium and the hook of the unciform are met with. At this point great care must be taken to keep the edge of the knife turned towards the bones, while firm traction is exerted on the flap. If this be done it will usually be found that the anterior annular ligament and median nerve have been raised in the flap. When the palmar flap has been raised, a curved incision is made across the back of the wrist, with its convexity downwards, connecting the two extremities of the previous incision and marking out a flap almost one inch in length. The wrist being forcibly flexed, the joint is now opened, and the ligaments divided. The hand is attached now only by the flexor tendons, which may be divided by a single sweep of the knife—the palmar flap being carefully held out of the way. The palmar flap will be found usually to contain the median and ulnar nerves and the superficial palmar arch, with portions of the muscles of the thumb and little finger.

It is better to cut the two nerves short, in order to prevent their implication in the cicatrix.

The most common error in performing this operation, and one which must be carefully guarded against, is commencing the incision for the palmar flap too much towards the palmar aspect of the wrist, instead of starting from the apices of the styloid processes. The base of the flap may thus be left very thin and narrow. In the after-treatment it is better to place the stump supinated on a pillow above the patient's head, so that it may drain better, and the flap have less tendency to displacement.

Amputation of the Fore-arm is not unfrequently required for disease or injury of the wrist or hand. In performing this operation, as long a stump should be left as possible, so as to give the patient more power over any artificial limb that may be fitted to it. The operation may be done by equal dorsal and palmar flaps. In a muscular limb each flap must be well rounded and equal in length to the antero-posterior diameter of the limb at the point at which the bones are sawn, as the palmar flap especially has a great tendency to retract. In amputating the right fore-arm, the Surgeon stands above the arm, so as to have his left hand to the dorsal flap, which he will have to raise by dissection. The hand being pronated, the incision for the dorsal flap is commenced at the palmar aspect of the radius, is carried forward for the necessary distance parallel to this bone, and then across the back of the arm in a slightly curved line, until it reaches the palmar aspect of the ulna; it then passes along this until it reaches a point opposite to that at which it was commenced, and the flap thus made is dissected back. Care must be taken that this flap is wide enough at its free extremity; it should in fact be a rectangular flap with its corners rounded off. The palmar flap is next made by transfixion (Fig. 45). As soon as it is cut, the bones are cleared by a couple of sweeps of the knife, and the interosseous membrane is divided; the bones are then sawn together. The vessels are cut long and will be found on each side of the palmar flap at the free end. In operating on the left side of the body, the Surgeon stands below the arm, with his left hand, as before, to the flaps, and the incision is commenced from the ulnar side.

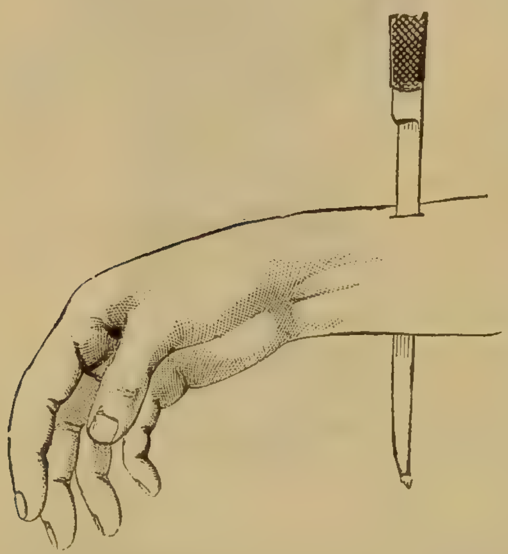


Fig. 45.—Amputation of the Fore-arm. Transfixion of the Anterior Flap.

When the palmar flap is formed by transfixion in amputation of the fore-arm, considerable inconvenience is often caused by the protrusion of the mass of tendons and muscles included in it. To avoid this, both flaps may be made by cutting from without inwards. It is advisable to make the dorsal flap a little longer than the palmar, so that the line of the cicatrix may fall well away from the ends of the bones. The operation may be thus performed (Fig. 46). The Surgeon, standing so as to take the flaps in his left hand, and holding the

arm with its dorsal surface upwards, enters the knife at the palmar edge of the bone furthest from him. He then marks out a flap from the dorsal surface, equal in length to two-thirds of the antero-posterior diameter of the limb at the point where it is intended to saw the bones. The flap must be sufficiently broad, and rounded at its corners. After raising this, taking only the skin and fat, a flap similar in shape, but half the length, may be raised from the palmar surface in the same way. This flap must be marked out by drawing the knife under the limb while it is still in the pronated position, but the fore-arm must be supinated while it is being dissected up. The knife is now firmly swept round the bones at the level of the angle of the flaps (Fig. 46), so as to divide the muscles circularly at this point. The soft parts are now to be retracted from the bones by a process of careful dissection, for a distance of from three-quarters of an inch to one inch, and the bones cleaned and sawn at this point. The result is, that the bones are buried in the muscles, and

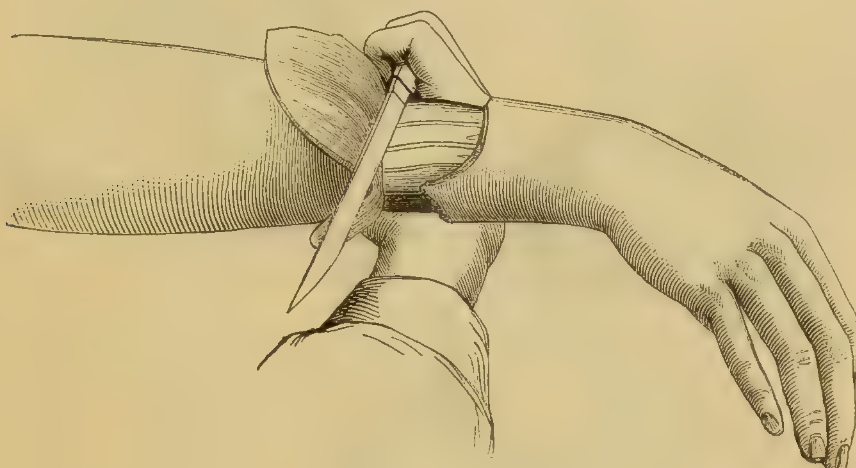


Fig. 46.—Amputation of the Fore-arm by Skin Flaps.

over all lie the light skin flaps, free from any tension or tendency to displacement. There will be a dependent opening for the exit of discharges, and, when healed, the cicatrix will be well to the palmar aspect of the bones, and consequently free from pressure. It may be found, in retracting the muscles from the bones, that the anterior interosseous artery has been cut in more than one place. This may cause some trouble in securing it. Great care should therefore be taken to avoid the accident, by keeping the edge of the knife constantly turned towards the part to be removed. If the median and ulnar nerves are seen to be cut somewhat long, they should be pulled out with forceps, and cut short, so as to avoid, if possible, their implication in the cicatrix near the end of the bone.

Amputation of the Arm is most readily performed by lateral flaps made by transfixion from before backwards; the bone is then well cleared by a couple of sweeps of the knife, and sawn across. In clearing the bone, care must be taken fairly to divide the musculo-spiral nerve by a firm sweep of the knife round the back of the bone (Fig. 47), if the amputation be performed in that part of the arm where this nerve winds round the humerus. The operation is also frequently performed by antero-posterior flaps. In this method the anterior flap is made to include the biceps and brachialis anticus, and the posterior contains the triceps. The brachial artery and the median nerve may be left

in either flap as may seem most convenient to the operator, but care must be taken that the artery is not pierced during the transfixion. It is sometimes recommended to cut the anterior flap longer than the posterior, but it is better as a rule to make the two flaps of equal length, as it enables the operator to saw the bone at the lowest possible point. If the limb be very muscular, the pure circular or the modified circular (pp. 54 and 62) will give the best result.

Amputation at the Shoulder-joint may be required for injury of the arm or for disease of the humerus; in the first case it may be performed by *transfixion*; in the other, by *cutting from without inwards*. Hæmorrhage during the operation must be prevented by the means described at page 43.

In operating by *transfixion*, a long-narrow-bladed knife should be used. One assistant must have charge of the limb; another should raise the flap;

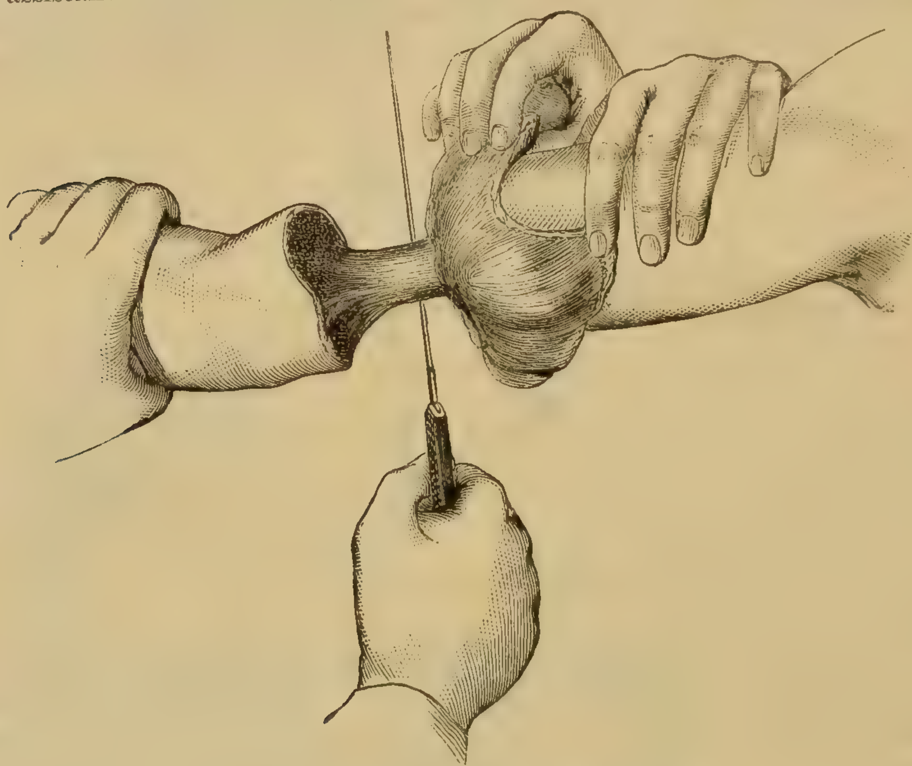


Fig. 47.—Amputation of the Arm. Clearing the Bone.

and a third must follow the knife as it cuts behind the humerus, and grasp the inner flap with the axillary artery, so as to prevent hæmorrhage from this vessel. An assistant holding the arm away from the body, so as to relax the deltoid, the knife, instead of being entered by a puncture, should make a small cut, about an inch in extent, to the point at which transfixion is to be made, so as to prevent that jagging of the integuments by the heel of the instrument which would otherwise occur. If the operation be on the *right* side, the Surgeon stands before the patient, and the point of the knife should be entered midway between the acromion and the coracoid process (Fig. 48); and being carried directly across the joint and capsule, should pass out well behind the acromion, and about an inch below the spine of the scapula. If on the *left* side, the Surgeon stands behind, and the point of the knife must be entered well behind the acromion below the spine of the scapula, at the posterior border of the axilla, carried across the anterior aspect of the joint, and brought

out on the outer side of the coracoid process. In either case, the large flap containing the deltoid muscle must then be cut by a sweep of the knife downwards, and raised by the assistant. The heel of the knife is now to be laid on the head of the bone, the capsule of the joint cut across, and the attachments of the muscles to the tuberosities divided. In order to facilitate this part of the operation, it is generally recommended that the arm should be carried forcibly inwards across the chest. This may readily be done in the dissecting-room, or in actual practice when the limb is removed for disease of the humerus, the bone being entire; but in the case of com-

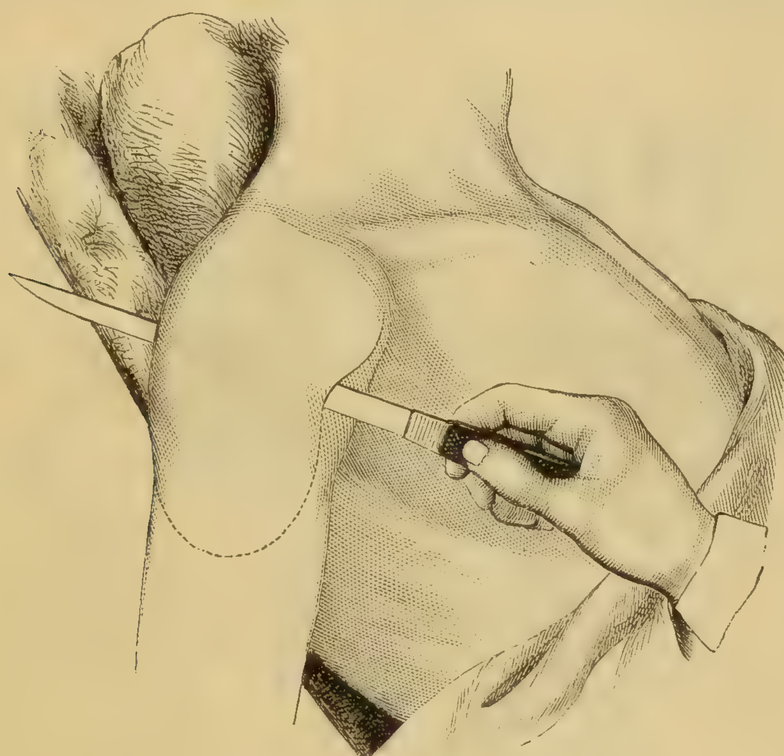


Fig. 48.—Amputation at the Shoulder-joint by Transfixion.

minuted fracture of the humerus, with extensive laceration of soft parts, it is useless to attempt this manœuvre. In a case of this kind, the head and upper end of the humerus being broken off from the shaft, the lever-like action of the bone cannot be put in force, and it is sometimes not such an easy matter as might at first appear, to detach the head from the glenoid cavity. In order to do this, I have, in cases of comminuted fracture of the humerus, in which I was amputating at the shoulder-joint, found it necessary, after opening the capsule, to seize hold of the upper fragment and to draw it forcibly downwards and outwards by inserting the fingers between the head and the glenoid cavity, in order to divide the muscles inserted into it. After the head of the bone has been turned out of the glenoid cavity, the knife must be passed over it and carried down for a distance of about three inches close to the bone at its inner side (Fig. 49). The Surgeon then cuts across the soft parts, so as to form the inner flap. While he is doing this, the assistant to whom this part is entrusted, must follow the knife with his hands, grasping firmly the whole thickness of the inner flap, so as to compress the axillary artery, and thus prevent the occurrence of hæmorrhage (Fig. 50). The Surgeon should not

finish cutting the flap until the assistant tells him that he holds the vessel firmly, and then he must be cautious not to injure his assistant's fingers. The artery will be found to be cut long in the middle of the inner flap, and a few smaller branches may require to be tied at its inner angle, and in the deltoid. The stump after it is healed will present the appearance shown in Fig. 52.

Unless the deltoid is well developed and well covered by subcutaneous fat, it is usually impossible to make a flap sufficiently wide to form an efficient covering by transfixion in this way, and it must then be raised by dissection. The line of the incision through the skin corresponds exactly with that just

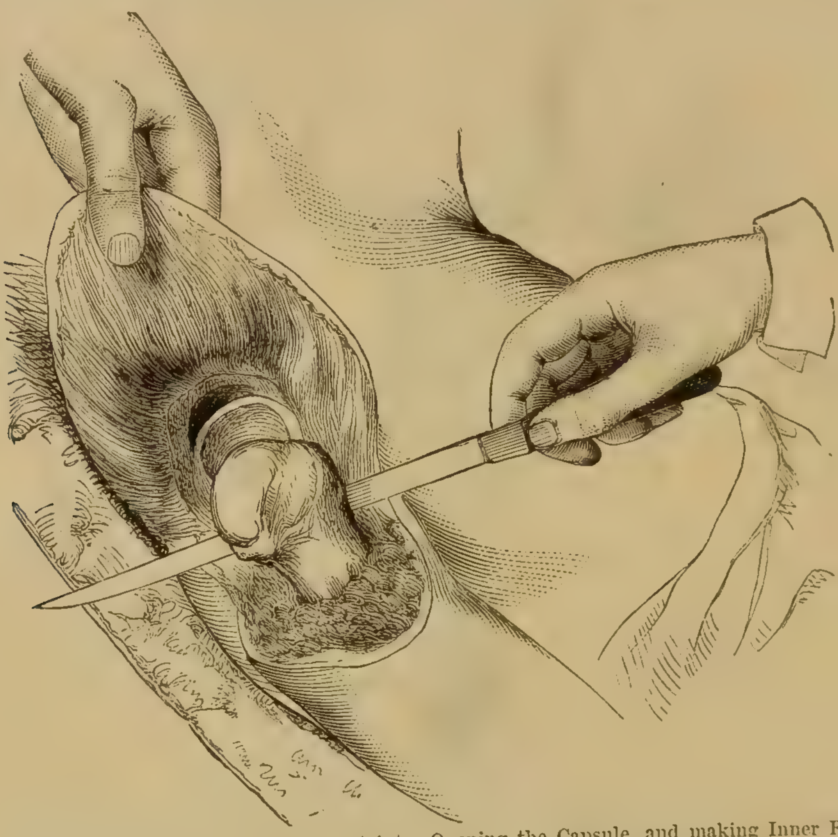


Fig. 49.—Amputation at the Shoulder-joint. Opening the Capsule, and making Inner Flap.

described. In operating on the right side the Surgeon, standing below the shoulder, grasps the arm and carries it slightly over the trunk; he then commences his incision well behind the acromion, and a short distance below the spine of the scapula, near the posterior fold of the axilla, carrying it downwards to the level of the insertion of the deltoid, and upwards to a point a little external to the coracoid process. He thus follows the ordinary rule of cutting from his left hand to his right. On the left side the direction of the incision is reversed. The deltoid being dissected up, the joint is opened and the inner flap cut in the usual way. The deltoid flap may be raised by means of a short knife, should the operator prefer it; a broad bistoury is very convenient. It must be changed for a long amputating knife after the joint is opened. This method of operating is specially adapted to cases of disease, and more particularly of tumour of the humerus, by which the soft parts are stretched and thinned. I have in this way easily performed amputation at the shoulder-joint for large tumours of the head of the humerus.

Amputation by antero-posterior flaps, or Lisfranc's method, differs some-

what from the operation described above. It is thus performed :—If it is the left arm that is to be removed, the Surgeon grasps the limb as near the elbow as possible, and carries it outwards nearly to a right angle with the trunk. He then inserts the knife immediately in front of the posterior fold of the axilla, and passing it upwards, so that it crosses the neck of the humerus at its posterior aspect, immediately below the head, he makes the point emerge just anterior to the acromion. The knife is then brought out in such a way as to cut a neatly rounded flap some four inches or more in length from the posterior aspect of the limb. The arm is then crossed over the body, the joint

Fig. 50.—Amputation at the Shoulder-joint. Holding Vessels in the Inner Flap.

opened, and the operation finished in the same way as that previously described. In operating on the right side the transfixion is made from immediately in front of the acromion to the posterior border of the axilla. The great rapidity with which this operation can be performed caused it to be highly appreciated before the invention of chloroform. It leaves the scar, however, in a more exposed situation than when a pure deltoid flap is raised.

Amputation at Shoulder by Oval Method.—In cases in which, from the state of the bone, the manipulations necessary for amputation by transfixion are impossible, the method originally invented by Larrey, or some modification of it, must be adopted. Larrey commenced his operation by a vertical incision down to the bone, about two inches in length, commencing immediately below the acromion process. From the end of this he made a curved incision on each side, reaching to the corresponding fold of the axilla. The two flaps thus formed were dissected up, and the head of the bone disarticulated. The knife was then passed internally to the head of the bone, and carried downwards while an assistant followed it with his hands to compress the axillary artery.

The operation was completed by dividing the tissues in the axilla, between the ends of the two curved incisions previously made to its borders.

The most important modification of this method is that of Spence, which is specially adapted for gun-shot wounds of the upper end of the humerus. It consists in carrying the vertical incision further forwards, and commencing it just external to and below the tip of the coracoid process, as in excision of the shoulder-joint. The incision ought to expose the tendon of the long head of the biceps lying parallel to it. This may be turned on one side, and the joint opened and examined; and if from the state of the parts it be still con-

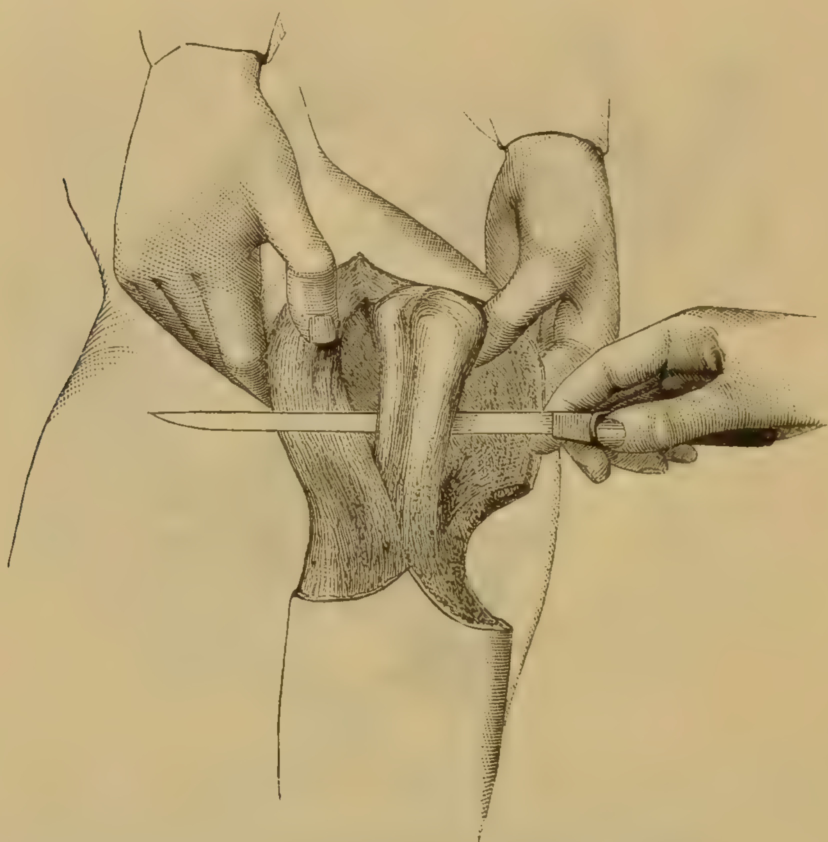


Fig. 51.—Amputation at Shoulder by Spence's Method.

sidered necessary to amputate, the operation is completed by making an oval incision through the skin from the end of the original cut, taking care not to go so deeply on the inner side as to wound the vessels. The outer flap is then dissected up, so as to enable the Surgeon to get his knife internal to the head of the bone, between it and the axillary artery (Fig. 51). The assistant follows the knife with his hands, and grasps the vessels, and the operation is finished by dividing the tissues left uncut at the inner side.

In this mode of operating much loss of blood may be saved by securing the vessels cut in the first part of the operation before opening the joint and proceeding to the division of the tissues at the inner side of the arm.

General Results of Amputations of the Upper Limb.—Amputations of the upper extremity, even for injury, are extremely successful. In the Crimea, amputations of the fore-arm were fatal in the ratio of 5, and those of the arm of 24·5 per cent. Max Schede, who has collected the statistics of the opera-

tions from the medical reports of all the chief wars since the peace of 1815, gives the following results for amputations of the fore-arm; primary, 1034, with 100 deaths, or 9·7 per cent.; intermediate, 454, with 109 deaths, or 24 per cent.; secondary, 242, with 62 deaths, or 25·6 per cent.; time not stated, 719, with 250 deaths, or 34·8 per cent.

The Table at p. 82, in the last chapter, gives a mortality of 34·4 per cent. for amputations for injury of the upper arm, and of 10·5 per cent. for amputation of the fore-arm. At Guy's Hospital, Bryant states that amputations for injury of the fore-arm were fatal in the ratio of 16, and those of the upper arm of 22 per cent. At University College, in Liston's and my practice, of 12 amputations for injury of the upper arm, there were 5 deaths; whilst of 8 in which the fore-arm was removed, all recovered. The cause of death was in most cases pyæmia, erysipelas, or septicæmia.

Amputations of the fore-arm and arm for disease, more particularly for strumous affections of the bones and joints, are very successful operations; when they are done for malignant disease, the risk is greater. In the table already referred to, the mortality after amputation of the arm for disease is 26 per cent., and of the fore-arm 15·9 per cent.

Max Schede gives in his tables the result of a collection of the cases reported as having been operated on in large hospitals for the twenty years previous to 1880. They are as follows: amputation of the arm for injury, 1167 cases, 364 deaths, or 31 per cent.; for disease, 441 cases, 81 deaths, or 18·4 per cent.: amputation at the elbow-joint for injury, 23 cases, 6 deaths, or 26 per cent.; for disease, 8 cases, 1 death or 12·5 per cent. Amputation of the fore-arm, 1316 cases, 143 deaths, or 10·8 per cent.; for disease, 506 cases, 62 deaths, or 12·2 per cent. Amputation at the wrist for injury, 199 cases, 5 deaths, or 2·5 per cent.; for disease, 27 cases, 0 deaths.

Amputation at the shoulder-joint for injury, although necessarily more fatal, is very successful for so severe a procedure. In 46 recorded cases in civil practice, there were 26 deaths, or 56·5 per cent., while of 607 cases in military surgery, 294, or 48·4 per cent., died. In the French army in the Crimea, of 222 cases, 137 died, or 61·7 per cent.; while in the English army during the same war, the mortality was only 35 per cent., and in the war of the American rebellion, it was 39·2 per cent. At University College Hospital, I have done the operation six times with one fatal result. When this operation proves fatal, the patient usually sinks from exhaustion, or is carried off by erysipelas or gangrene of the stump.

Amputation at the shoulder-joint for disease of the humerus is a very successful procedure, considering the size of the part removed, and its proximity to the trunk.

Max Schede's tables show the following results: amputation at the shoulder-joint in civil practice for disease, 188 cases, 33 deaths, or 28 per cent.; for injury, 274 cases, 116 deaths, or 42·3 per cent. In military practice: primary, 585 cases, 142 deaths, or 24 per cent.; intermediate, 175 cases, 82 deaths, or 46·8 per cent.; secondary, 140 cases, 59 deaths, or 42·1 per cent.; time not stated, 851 cases, 414 deaths, or 55·1 per cent. The very high death-rate amongst those in which the time of operation is not stated, arises from the fact that all the French operations during the Crimean War come entirely in that class, and the mortality amongst all the French wounded during that campaign was exceptionally great. If these are excluded, the

death rate is only 24 per cent. The combined results of Socin, Volkmann, Max Schede, and Busch, of cases treated by the antiseptic method show results much more favourable than those above given. Excluding double amputations, cases with fatal injuries distinct from that for which the operation was performed, cases operated on for spreading gangrene, pyæmia or septicæmia, the following results are obtained. Shoulder-joint, for injury, 4 cases, 1 death (shock in four hours); disease, 5 cases, 0 deaths; arm, for injury, 20 cases, 0 deaths; for disease, 12 cases, 0 deaths; fore-arm, for injury, 34 cases, 0 deaths; for disease, 13 cases, 0 deaths. The reports of Bardeleben Billroth and Bruns, published before the invention of the anti-septic method, excluding, as before, all complicated cases, give the following results: shoulder-joint for injury, 9 cases, 5 deaths; for disease, 6 cases, 3 deaths; arm, for injury, 22 cases, 6 deaths; for disease, 19 cases, 0 deaths; fore-arm, for injury, 20 cases, 1 death; for disease, 22 cases and 2 deaths.

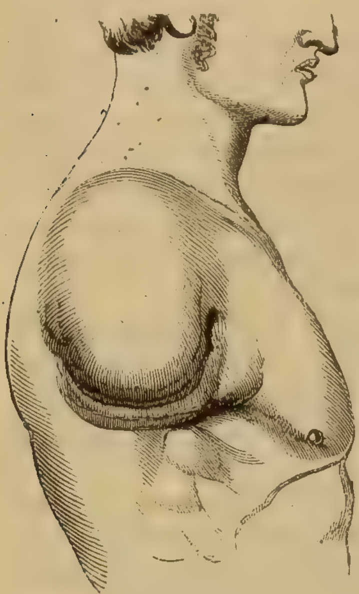


Fig. 52.—Stump after Amputation at the Shoulder-joint.

Amputations of the Foot.—The **Phalanges of the Toes** seldom require amputation: when they do, they may be removed in the same way as the corresponding parts of the hand—by the formation of a flap on the plantar surface, either by cutting from above downwards, or by transfixion.

In removing a bone at the **Metatarso-phalangeal Articulation**, the oval method should always be practised, so that the sole of the foot may not be cut into. In doing this it must be remembered that the articulation is situated considerably above the web of the toes, and the incision must therefore be commenced proportionately far backwards (Fig. 53). As a general rule, it will be found that the articulation is about the same distance above the web as the point of the toe is below it. Another guide to the joints is obtained by drawing a line straight across the foot from the metatarso-phalangeal joint of the great toe, which can usually be clearly felt.

In removing any of the three middle toes, those on each side must be forcibly separated, and at the same time flexed as much as possible by pieces of bandage passed round them. The toes are too short to be held aside satisfactorily by the fingers of the assistant. The forcible flexion of the neighbouring toes renders the articulation more superficial and greatly facilitates the operation.

Amputation of the Great Toe is frequently required for injury and for destruction of the metatarso-phalangeal joint by extension of inflammation into it from a suppurating bunion. In such cases the head of the metatarsal bone should never be removed if it can possibly be saved, as it forms the anterior extremity of the arch of the foot on the inner side, and its loss tends to cause the foot to turn outwards. It is a common error in this operation to leave an insufficient covering for the head of the bone, the great size of which should always be borne in mind. To avoid this the operation should be performed by the racket-shaped incision, the oval part of which should not

commence till the knife has reached the middle of the proximal phalanx, and should pass, on the inner side, over the line of the articulation between the two phalanges. This amount of covering will not be found more than sufficient. In operations for injury it is not always possible to save so much, but all should be preserved that can be.

Anatomical Guides in the Foot.—In operating on the foot beyond the removal of separate toes, certain anatomical guiding points must be kept in mind, some of which are usually perceptible even in cases of disease. Opposite the ankle-joint are the two malleoli. The tips of these, it must be remembered, are not opposite each other, the external being the lower

Fig. 53.—Incision and Position of Joint in Amputation of a Toe.

and posterior, so that when, in Syme's operation, or in Pirogoff's, the direction is given to cut from the tip of the outer malleolus to the corresponding point on the other side, it means to a point a little behind and below the inner malleolus.

The next point of importance on the inner side is the tubercle of the scaphoid, which forms a rounded prominence about half an inch in width. Its posterior border corresponds to the articulation between the scaphoid and the head of the astragalus and its anterior to that between the scaphoid and the internal cuneiform. The internal cuneiform is about one inch in length, so, at that distance from the anterior edge of the tubercle of the scaphoid, will be found the articulation between the cuneiform and the metatarsal bone of the great toe, immediately in front of which is the well-marked tubercle at the base of that bone. On the outer side, below and a little in front of the external malleolus, is the outer tubercle of the os calcis, which is often but indistinctly felt. About the middle of the foot the tubercle at the base of the fifth metatarsal bone forms a very marked prominence. Mid-way between the base of the fifth metatarsal bone and the tip of the external malleolus is situated the articulation between the cuboid and os calcis; and this point is exactly opposite the tubercle of the scaphoid on the inner side.

The **Metatarsal Bone of the Great Toe** occasionally requires removal in whole or in part. The whole of the bone may be readily removed by one of two methods: 1, by the flap; 2, by an oval amputation.

1. The *Flap Amputation* is done as follows. The point of a strong, broad bistoury is entered on the dorsum of the foot over the interspace between the first and second metatarsal bones, as far back as possible; it is then carried forwards upon the ball of the great toe, to a point opposite to the web between the toes, and thence made to sink into the sole of the foot in a line parallel to the outer margin of the bone; the flap thus formed is dissected back, its plantar aspect being kept as thick and fleshy as possible (Fig. 54). The Surgeon next passes the knife between the first and second metatarsal bones,

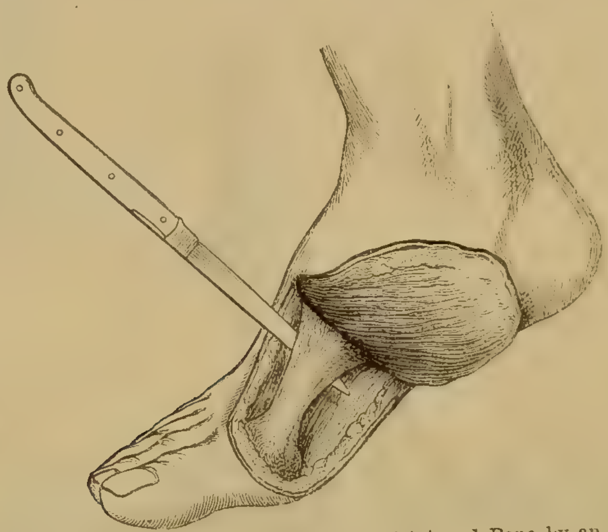


Fig. 54.—Amputation of the Great Toe and its Metatarsal Bone by an Internal Flap.

and cuts directly forwards through the centre of the angle between the great and the second toes. In doing this, care must be taken that the edge of the knife is not directed too much towards the metatarsal bone of the great toe, lest it hitch against one of the sesamoid bones. The Surgeon next seizes the extremity of the toe, and, pulling it well inwards, passes the point of the bistoury deeply into the angle of the wound (Fig. 54), where, by the division of some tendinous and ligamentous fibres that constitute the key of the joint, he opens the articulation, and detaches the bone by lightly touching its ligamentous attachments. By keeping the edge of the knife well against the side of the bone, he may avoid wounding the dorsal artery of the foot, the bleeding from which would be troublesome. When the bone is to be partially removed, the operation must be performed in the same way; the incisions, however, not being carried so far backwards.

2. In *Amputation by the Oval Method*, the point of the bistoury is entered on the dorsum of the foot, just behind the tarsal end of the bone. An incision is carried up to the digital interspace, and is made to circle round the base of the first phalanx, so as to join the first line of incision on the dorsum (Fig. 55), taking care not to commence the oval part too soon. The soft structures on the inner side are then dissected down, the knife being kept close to the bone. The same process is carried on at the outer side, the blade being made to sweep under the bone from without inward, and the joint opened as described in the flap operation.

This process has the advantage of leaving the sole uninjured. It has the disadvantage of favouring an accumulation of pus at the deeper part of the wound.

The operation may be greatly facilitated, and the tendency to accumulation of discharges diminished by commencing the incision at the side of the foot immediately behind the tuberosity at the base of the metatarsal bone, one inch

Fig. 55.—Amputation of the Great Toe by Oval Method.

in front of the tuberosity of the scaphoid. It is then carried towards the dorsum of the foot, following the line of the articulation; on reaching the dorsum it is curved sharply round into the line of the metatarsal bone, and the operation finished as just described.

3. If the disease be limited to the anterior part, the shaft of the bone should be cut across with a pair of bone-nippers, and its base left.

The **Metatarsal Bone of the Little Toe** may conveniently be removed by an oval incision, so as to avoid wounding the sole of the foot. This is best

Fig. 56.—Amputation of the Little Toe and its Metatarsal Bone by the Racket-shaped Incision.

done by entering the point of the knife just behind the tubercle of the bone, carrying it forwards and inwards in the line of its articulation with the cuboid, to the centre of the fourth digital interspace, and thence forwards to the web of the toe; the knife is next carried round the plantar surface of this, the incision being continued obliquely into that which has been made on the

dorsum of the foot (Fig. 56). The small flap thus formed is dissected well down, the knife passed round the under surface of the bone, and the joint opened by the toe being forcibly drawn outwards, and its ligamentous connections lightly divided.

The middle metatarsal bones, when diseased, do not admit of separate removal so as to leave a foot that would be useful to a patient.

Amputation of the Metatarsus.—When the metatarsus and anterior part of the foot are diseased or injured so as to require removal, the amputation may be effected by one of two methods; viz., 1. By making a flap from the sole and a transverse incision across the dorsum, and then sawing across the metatarsus as a whole above the seat of injury or disease; or, 2. By disarticulating the metatarsus from the tarsus.

The first operation—that of sawing through the metatarsus—is sometimes called Lisfranc's; but in reality it was practised and described by Hey long before Lisfranc's time. By "Hey's Amputation" is usually meant the disarticulation of the metatarsus from the tarsus, and the formation of a flap from the anterior part of the sole of the foot. But Hey describes three different amputations, only one of which corresponds to this method. In his "Practical Observations, London, 1814," p. 550, he says, "I have judged it to be the safer method to take away all the diseased integuments by a transverse and a longitudinal incision made at right angles to each other, and then to saw off the metatarsal bones as far as the morbid integuments extended."

At p. 553 he says, that in operating on a girl about 18, a method suggested itself to him "of finishing the operation, which proved highly advantageous to the patient. Having dissected out the metatarsal bones and removed the toes by a transverse incision made at their junction with the metatarsal bones, I elevated the integuments and muscles forming the sole of the foot, &c." This operation was done in the year 1797.

In the year 1799, p. 554, he states that he operated as follows. "I removed all the toes at their junction, with the metatarsal bones, and then separated the integuments and muscles, forming the sole of the foot, from the inferior part of the metatarsal bones, keeping the edge of my scalpel as near the bones as I could. . . . . I then separated with the scalpel the four smaller metatarsal bones at their junction with the tarsus, which was easily effected, as the joints lie in a straight line across the foot. The projecting part of the first cuneiform bone which supports the great toe, I was obliged to divide with a saw."

Thus it would appear that in the first case Hey *sawed across* the metatarsal bones after having made the flap. In the second case, he *dissected out* all the metatarsal bones, and then made a flap from the sole. In the third case, he first made the sole-flap, and then, having *dissected out* the four smaller metatarsal bones, *sawed* across the internal cuneiform; thus combining the two methods of cutting and sawing.

In order to avoid any possibility of error, it is better to discard the terms Hey's and Lisfranc's operation, and to describe these operations as "amputation through the metatarsus," and the "tarso-metatarsal amputation."

The *whole of the Metatarsus* may be removed from the tarsus by the operation originally planned and executed by Hey. This consists in first of all making, in the sole of the foot, a curved incision reaching to the roots of the toes, one horn of which commences at the tubercle of the fifth metatarsal bone,

whilst the other terminates at that of the first, or one inch in front of the tubercle of the scaphoid. The flap thus marked out is carefully raised, taking skin and fat only for the first inch, and after that all the soft parts down to the bone. On the left side the direction of the incision is reversed.

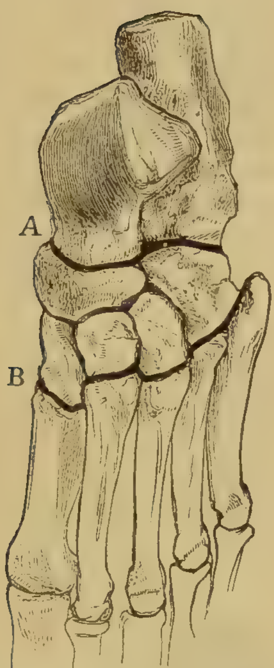


Fig. 57.—B. Line of Hey's, or Tarso-Metatarsal, Amputation. A. Line of Chopart's, or Medio-Tarsal, Amputation.

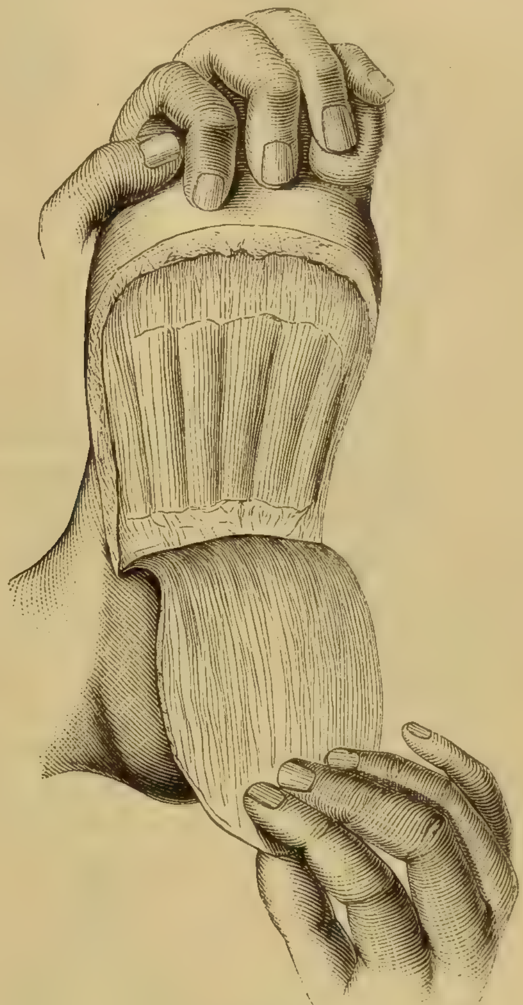


Fig. 58. — Chopart's Operation. Flap formed before Disarticulation.

A small flap is then made on the dorsum of the foot and the articulations are exposed. These must then be opened with some care, as they are very irregular (Fig. 57); the second metatarsal bone, especially, being sunk into a kind of pit between the inner and outer cuneiform bones, and the articulation of the fifth, with the cuboid, being very oblique. The line of the articulation is best found by forcing downwards the anterior part of the foot, while the point of the knife is drawn across the line of the joints. As each is touched it will gape slightly, but they are prevented from opening fully by the very strong interosseous ligament which passes between the outer side of the internal cuneiform and the base of the second metatarsal bone. This can be divided only by forcing the knife upwards between the two bones, taking care while so doing not to wound the base of the sole flap with the point. As soon as this ligament is divided, the whole line of joints readily breaks open, and dis-

articulation is performed without further difficulty. This operation is seldom practised, disease being rarely limited to the metatarsal bones, but usually implicating the joints as well. Their disarticulation from the tarsus is, moreover, very troublesome, on account of the irregularity of the line of articulation ; hence it is better to saw through the metatarsus just in front of the tarsal articulations, than to attempt to disjoint the bones. A combination of these two procedures may sometimes be advantageously adopted. In several of those severe crushes of the anterior part of the foot, that are not unfrequently the result of tram-car or railway injury, and in which the bones and soft parts are irregularly crushed and torn, I have made a very excellent stump by disarticulating the first and the fifth metatarsal bones, and sawing across the three middle ones almost an inch anterior to their articulations with the tarsus, or by simply dissecting back the sole of the foot, clearing the bones, and sawing them across at a convenient line.

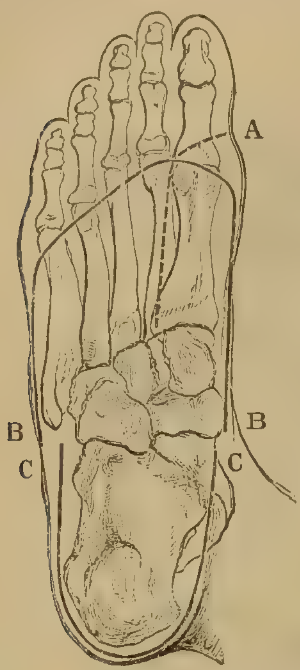


Fig. 59.—A. Line of Incision for Amputation of Great Toe and Metatarsal Bone. B. Line for Chopart's Amputation. C. Line for Excision of the Os Calcis.

Amputation through the Tarsus may conveniently be performed by Chopart's, or the medio-tarsal, operation, which consists in disarticulation in the line between the os calcis and astragalus behind, and the cuboid and scaphoid in front (Fig. 57). This operation may be performed in two ways,

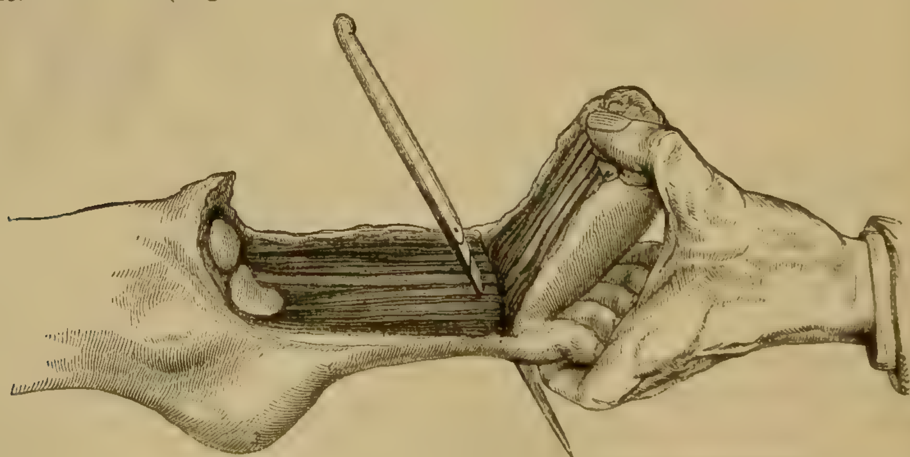


Fig. 60.—Chopart's Amputation. The Flap being cut after Disarticulation.

either by first making the flap from the sole of the foot, and then disarticulating (Fig. 58) ; or, the joints having been cut through from the dorsum, the flap may afterwards be made (Fig. 60). In the latter plan a smoother end will be obtained by transfixing the flap as in Figure 60, and cutting it in two parts from the middle. I prefer the first plan, as it enables the Surgeon to make a more correctly fashioned flap.

In operating on the *left* foot, the knife, a stout bistoury, should be entered immediately behind the tubercle of the scaphoid, and carried forwards to about the head of the metatarsal bone of the great toe, then right across the sole, and down the outer side of the foot, as far as mid-way between the tip of the external malleolus and the base of the fifth metatarsal bone. The two guiding points are exactly opposite each other, and if one is concealed by the swelling of the foot, the other can usually be found.

On the right foot this line of incision is reversed by the knife being entered half an inch behind the metatarsal bone of the little toe, carried forwards to the root of the toes, across the sole, and down the inner side to behind the tubercle of the scaphoid (Fig. 59, B.). This flap should be made long, especially at the inner side, but well rounded at the angles, and should consist of the whole thickness of the parts in the sole of the foot, which must be well dissected out from the concavity under the metatarsal bones. But in children and young adults, in whom the foot is often long and the tarsus thin, the flap need not be made so long. The sole flap having been raised, a convex incision is made over the dorsum from one horn to the other of the plantar flap; the parts are well retracted, and the articulations opened by the Surgeon bearing firmly upon the anterior part of the foot, and lightly touching the ligamentous structures with the point of his bistoury. In this stage of the operation, care must be taken that the edge of the bistoury be not inclined too much backwards, lest it slip over the astragalus and open the ankle-joint; or too far forwards, lest it pass anterior to the scaphoid—between it and the cuneiform bones. After disarticulation has been produced, the projecting head of the astragalus and the articular surface of the os calcis should be sawn off. In more than one instance, I have found firm osseous ankylosis existing in the line of articulations, requiring the use of the saw for the separation of the anterior part of the foot. When this complication occurs, the tarsus should be treated as a whole, and sawn through, irrespective of articulations, behind the limits of the disease. The result of this operation is extremely favourable, the patient, by the aid of a properly constructed boot, being able to walk, and even dance, with very little appearance of lameness. In some cases, where the muscles of the calf are very strong, the heel becomes drawn up, and the end of the stump is made to point down in such a way that the patient is rendered lame by walking on the anterior sharp edge of the calcaneum, which irritates the flap. Verneuil states that he has observed in a number of cases, that the heel is drawn up only in amputations for disease, and that it occurs really before the operation and not after. He has never noticed it in a primary amputation. This condition is best removed by division of the tendo Achillis.

The operations just described are adapted to cases of disease, as it is important not to leave a part of the affected bones behind, and their removal is made more certain by operating through the lines of the articulations. In amputations for injury, however, it has been recommended by Mayor, of Lausanne, and others, to treat the foot as a whole, ignoring articulations. On this plan, a sufficient covering is turned up, encroaching on the foot as little as the nature of the injury will allow. When sufficient covering has been obtained, the saw is applied to the tarsus or metatarsus, as the case may be, saving as much of the foot as possible. There is no doubt

that excellent results are obtained by this method, every half inch of the foot that can be saved adding to its utility.

Sometimes the exact limits of the injury are difficult to ascertain with accuracy immediately after the accident. In such cases any loose or absolutely crushed fragments may be removed, and the foot placed for a quarter of an hour in a bath of 1 in 20 carbolic acid lotion. It may then be dressed antiseptically, and the amputation deferred till the exact limits of the injury can be clearly ascertained. This line of practice was followed in two cases lately in University College Hospital. In one, the foot, which seemed at first hopelessly crushed, completely recovered; in the other it also recovered, with the exception of the great toe, which was amputated at the end of the second week.

Disarticulation of the Foot at the Ankle-joint was first reduced to

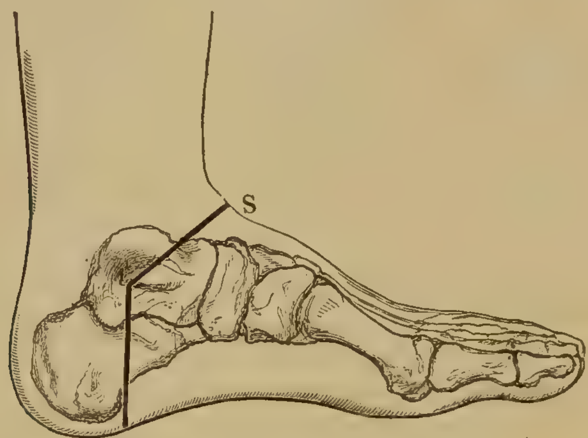


Fig. 61.—Syme's Operation. Inner Side of Foot.

a regular operation by Syme. By its performance amputation of the leg may often be avoided, the patient being left with an exceedingly useful stump,

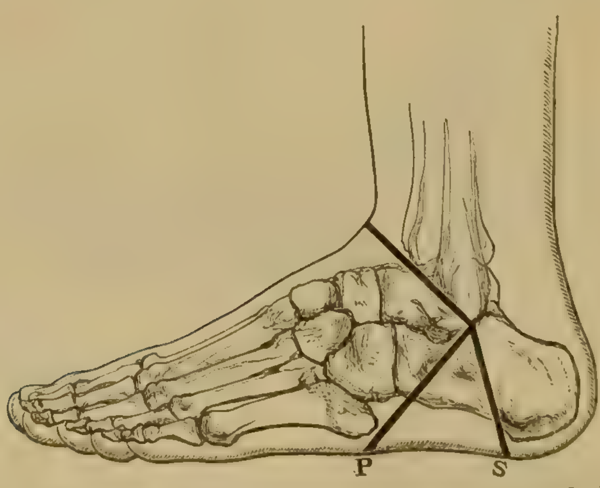


Fig. 62.—S. Line of Incision for Syme's Operation. P. Line of Incision for Pirogoff's Operation.

which, as its covering is ingeniously taken from the heel, constitutes an excellent basis of support. In describing the operation on the right foot Syme's words as to the direction of the incision are: "The foot being held at

a right angle to the leg, the point of the knife is introduced immediately below the malleolar projection of the fibula, rather nearer its posterior than anterior edge, and then carried across the bone, slightly inclining backwards, to the inner side of the ankle, where it terminates at the point *exactly opposite* its commencement" (that is, a little below and behind the internal malleolus). On the left side the direction of the incision is reversed. "The extremities of the incision thus formed are then joined by another passing in front of the joint. The operator next proceeds to detach the flap from the bone" (Fig. 63). The object of carrying the incision so far back is, that the dissection of the flap may commence from the most prominent point of the plantar surface of

Fig. 63.—Syme's Amputation of the Foot. Clearing the Os Calcis.

Fig. 64.—Syme's Amputation of the Foot. Anterior Incision and Disarticulation.

the os calcis, that is to say, from the anterior part of the two tubercles of that bone. Every eighth of an inch in front of this point increases the difficulty of raising the flap. When the heel flap is turned back, the ankle-joint must be opened in front by cutting firmly across the line of the articulation, which is about half an inch above the tip of the inner malleolus, while the foot is forcibly extended. As soon as the joint opens sufficiently the lateral ligaments are to be divided by cutting downwards between the malleoli and the lateral surfaces of the astragalus. The tendo Achillis is divided by pressing the foot forcibly downwards and cutting from before backwards, unless it has already been cut in turning back the heel flap. By twisting and dissecting at the same time the os calcis is completely separated from its soft attachments, and the foot removed (Fig. 64). The soft parts are then turned up from the lower ends of the tibia and fibula, the knife being kept close to the bones so as not to wound the vessels that lie immediately behind

each malleolus. The whole of the parts of the tibia and fibula which enter into the ankle-joint are then sawn off, the arteries tied and the flap brought up. A well-formed rounded stump will thus be left.

In performing this operation, care must be taken that no button-hole apertures be made through the posterior part of the heel flap. This may commonly be avoided readily enough when the soft structures in this situation are greatly thickened and infiltrated by plastic matter, as the result of chronic disease; but, if the operation be required for injury of the foot, great care is required in digging out the heel, the integuments at the posterior part of the os calcis being very thin and adherent to the bone. It is also of importance that the incision across the heel should be (Figs. 61, 62) distinctly inclined backwards towards the heel, and not forwards into the sole of the foot. Unless this be done, a large cup-shaped flap will be left, in which blood and pus will accumulate, and the cicatrisation of the stump will be much retarded. As union takes place by granulation, there will be a tendency to bagging in the stump; but this may be prevented by proper bandaging. The tendency to sloughing and to undue suppuration occurs chiefly in those cases in which the amputation has been performed as a primary operation for a crush of the foot. In one case in which I had occasion to perform it for one of these injuries, a good deal of trouble resulted from this cause, though eventually the case did perfectly well, and the patient now walks with scarcely any difficulty. It has been frequently stated that it is necessary, in order to ensure the vitality of the flap, to cut the posterior tibial artery "as long as possible," and it is this as much as anything that has led to the production of the huge cup-shaped flaps which are so difficult to dissect off the os calcis and which so often slough. A careful examination of the vascular supply of the flap will show at once that the posterior tibial artery may be cut close to the base of the flap, without in the least interfering with the chief vessels supplying it. The distribution of vessels to the part is as follows. On the outer side, the peroneal artery, after giving off the anterior peroneal, is continued down along the posterior aspect of the fibula to the outer side of the os calcis. On the inner side a branch of considerable size arises from the posterior tibial artery, about one inch above the ankle-joint, and passes down to the inner side of the os calcis, running behind the inner malleolus and accompanying the small cutaneous nerve from the posterior tibial to the skin of the heel. There is thus a main trunk on each side running down to the heel behind the malleolus, and these two communicate freely with each other superficially over the cutaneous surface of the tendo Achillis, and deeply between the tendon and the back of the ankle-joint; and they terminate by anastomosing again by long vascular loops on the under surface of the posterior part of the os calcis. It is upon these anastomosing loops that the vitality of the flap depends more than upon anything else; and as they lie much nearer the bone than the skin it is evident that, unless the knife be kept hard upon the bone during the whole dissection of the flap, they will be divided in large numbers, greatly endangering its vitality. In the operation as performed by Syme, the dissection of the flap is commenced from the most prominent part of the tubercles of the os calcis, and the knife can be kept in constant contact with the bone with the greatest ease. If, on the contrary, the flap extend far into the sole of the foot in front of the tuberosities of the os calcis, it is almost impossible to dissect it back without the point of the knife being directed into the under

surface of the flap and the vascular loops being divided. All the above-mentioned vessels can be readily dissected out in any well injected foot in the dissecting-room.

This operation is a most useful one in all cases requiring removal of the whole foot. The mortality attending it is but small. I have never known a

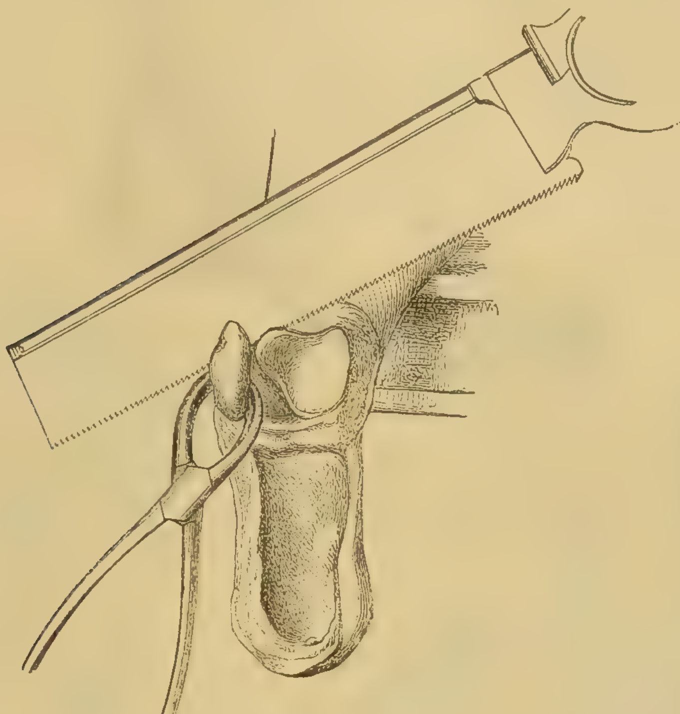


Fig. 65.—Syme's Amputation of the Foot. Sawing off the Malleoli.

fatal case. The stump that is left admits of good pressure being exercised directly upon it, without tenderness or fear of ulceration.

Various modifications of Syme's amputation may at times be practised with advantage, in consequence of the soft parts covering the heel being more or less ulcerated or disorganised, so as not to admit of forming a good basis of support. In these circumstances, the flaps may be fashioned from the sides instead of from behind; and in this way I have more than once formed an excellent covering to the end of the stump. These lateral flaps should not, however, be made in any case that admits of disarticulation at the ankle in the ordinary way. They never afford so good a basis of support as the integuments of the heel, which are far more dense and elastic.

Pirogoff's Amputation is characterised by the preservation of the posterior portion of the os calcis. The operation is performed in the following way. In operating on the right side, an incision is carried across the sole of the foot from the tip of the external malleolus to the corresponding point on the other side; when operating on the left foot the direction of the incision is reversed. This incision should not be made directly transverse to the foot, but should incline forwards obliquely, so that the centre of the incision in the sole may be at least one inch and a half in front of a line drawn transversely from the tip of one malleolus to the other (Fig. 66). It should reach, in fact, a little beyond the anterior extremity of the os calcis. The knife should

be then sunk in well down to the bones in the direction of the incision, care being taken in crossing the sole of the foot that the knife is not carried down

Fig. 66.—Line of Incision for Pirogoff's Operation—modified by Oblique Section of the Os Calcis.

to the bones at right angles to the sole, but is slanted obliquely backwards. Disarticulation of the astragalus is then effected in the usual way, by an

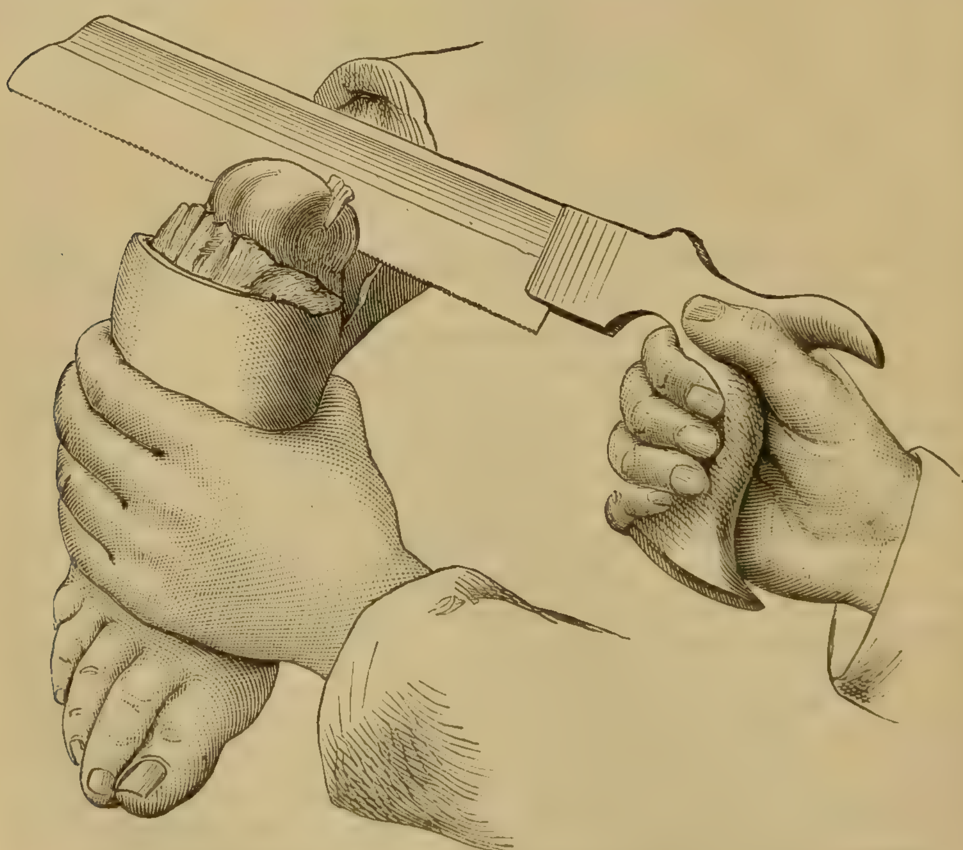


Fig. 67.—Pirogoff's Operation. Sawing the Os Calcis obliquely, downwards and forwards.

incision across the front of the foot. The foot is now forcibly extended to the greatest possible extent, and a common saw is applied immediately behind the

astragalus, and the bone cut obliquely downwards and forwards in the line of the incision in the soft parts, so that the saw should come out immediately behind the articulation of the os calcis with the cuboid (Fig. 67) ; the malleoli are then removed, with a thin slice of the tibia, including the whole articular cartilage (Fig. 68). The opposed osseous surfaces must then be accurately adjusted, the movable flap well supported by a broad strip of plaster, and the limb laid on the outer side, with the knee placed so as to take off the tension of the tendo Achillis. The advantages of the long oblique section of the os calcis over the shorter almost vertical cut originally made by Pirogoff are, as Busk has pointed out, that a larger surface of bone is brought into contact

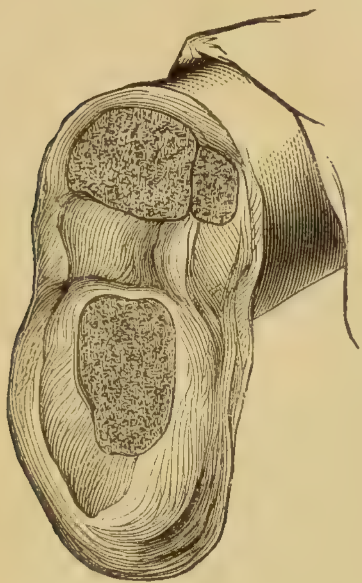


Fig. 68.—Pirogoff's Amputation. Appearance of Parts after Removal of Malleoli.

Fig. 69.—Stump after Pirogoff's Amputation.

with the sawn end of the bones of the leg, that the remaining piece of bone does not require to be tilted so much on its own axis, and that consequently the tendo Achillis is not put so much on the stretch, and that the thick skin of the heel, naturally in contact with the ground, still serves as the basis of support instead of the thin skin of the back of the heel, which is turned downwards in the other method. The alleged advantages of this operation over Syme's amputation consist in the stump being longer, to the extent of the thickness of the portion of the os calcis left in it, and being better adapted for pressure (Fig. 69) ; and in the less likelihood of the supply of blood to the posterior flap being interrupted, as its vascular communications are not much disturbed. These advantages are not, however, always real, and are in some degree counter-balanced by the liability to recurrence of disease in the portion of the os calcis left in those cases in which the amputation is done for disease. When it is practised for injury, however, this objection does not hold good. Another objection which has been raised against this operation, consists in the supposition that the section of two osseous surfaces exposes the patient to increased risk of osteophlebitis and pyæmia. In the first case in which I performed this amputation the patient, a healthy lad, whose foot was removed for injury, died from this cause. But subsequent and extended experience has

convinced me that there is no special liability to pyæmia after Pirogoff's amputation. After either Syme's or Pirogoff's operation, patients can run; which they cannot do after amputation of the leg in any part.

The **Subastragaloid Amputation** is another mode of disarticulating the foot. The incisions, as recommended by Nélaton, somewhat resemble those for Syme's operation, but are carried farther forwards, both on the dorsal and plantar aspects of the foot. In operating on the right foot, the incision is commenced about three-quarters of an inch below the external malleolus, opposite the outer tubercle of the calcaneum, and carried, at first forwards for a short distance, and then in a curved direction downwards to the sole of the foot, so as to pass just behind the base of the fifth metatarsal bone. It then crosses the sole, and is brought up to the inner side of the foot, terminating at the tuberosity of the scaphoid. The extremities of this line are then joined by a curved incision across the dorsum of the foot, reaching downwards to the lower edge of the scaphoid. The soft parts are then raised from the bone on the outer side, sufficiently to reach the tendo Achillis, which is to be divided. The finger, pushed into the wound, can now feel the upper surface of the calcaneum, and the line of articulation with the artragalus. The point of the knife is now to be thrust into the articulation, and the interosseous ligament divided, while the foot is wrenched forcibly inwards. Care must be taken not to injure the ligaments between the os calcis and cuboid, or all power over the former bone would be lost. When the interosseous ligament is divided, the astragalo-scaphoid articulation is to be opened, and finally, by twisting the foot so as to put the parts on the stretch, the soft parts at the inner side and the remainder of the heel flap, are to be separated from the os calcis and the foot removed. In this amputation a good, long, useful stump results; but the cases requiring it must be few, as it does not often happen that there is disease of the calcaneum together with the anterior range of tarsal bones, without the astragalus also being involved.

In cases of caries of the tarsus requiring amputation, it occasionally happens that the Surgeon cannot determine with certainty whether the morbid condition is limited to the anterior range of tarsal bones, or extends so far backwards as seriously to implicate the artragalus and calcaneum; and he is consequently unable to decide whether the condition of the foot admits of removal by Chopart's operation, or requires disarticulation at the ankle-joint. In these circumstances all doubt will be cleared away, and the proper operation performed, by making an incision across the dorsum of the foot in the line of the astragalo-scaphoid and calcaneo-cuboid articulations; these are then opened, and the state of the bones is examined. If the astragalus and calcaneum be sound, or but slightly diseased on their anterior aspect, Chopart's operation may be done, and any carious bone left behind gouged away. If, on the contrary, these bones be found to be deeply implicated, the flap may be dissected back for about an inch, and disarticulation at the ankle-joint proceeded with. It may also be well to bear in mind that the tarsal articulations may have become so ankylosed, as the result of old disease, as to require the application of the saw, instead of opening on division of their ligaments.

Results.—The amputation of a toe, of a metatarsal bone, or even of a portion of the metatarsus, is but very seldom attended by fatal consequences. Should death occur, it must be the result of an accidental attack of tetanus, erysipelas, or of pyæmia. Disarticulation at the ankle-joint, though necessarily

somewhat more dangerous, is yet one of the most successful operations in Surgery, the mortality attending it being but very small.

The following are the figures given in Max Schede's tables. Partial Amputations of the Foot for injury, in civil practice, 223 cases, 45 deaths, or 20·2 per cent. ; for disease, 562 cases, 70 deaths, or 12·4 per cent. In military practice, the numbers are 831 cases, with 388 or 46·7 per cent. of deaths ; but this fearful mortality has been chiefly in the French hospitals. If these are excluded, there remain 403 cases, with 65 deaths, or 16 per cent.

The statistics of uncomplicated cases from the practice of Socin, Volkmann, and Max Schede, under antiseptic treatment, show 65 cases, with 2 deaths, 1 in a woman, aged 77, and 1 re-amputation. Those of Bruns, Bardeleben and Billroth, in the pre-antiseptic period, show 39 cases, with 10 deaths, 8 of which were from pyæmia. The highest mortality was from Pirogoff's operation, of which there were 13 cases, with 5 deaths, 4 from pyæmia and 1 from erysipelas.

Amputation of the Leg may be performed in three situations : either just below the knee, in the middle, or in the lower third of the limb. The selection of the line of amputation must depend in a great degree upon the extent of the disease or injury, but, whenever practicable, the operation should be performed low down ; the mortality diminishing in proportion as the limb is removed near to the ankle. Of 106 amputations in this situation done in Paris, there were only 13 deaths. Surgeons used formerly, even where the disease or injury was limited to the foot, to amputate immediately below the knee, in all those cases in which the patient would be obliged to wear a common wooden pin, the long leg-stump being highly inconvenient when the patient rested on his bent knee ; whereas, in those individuals who could afford the expense of a well-constructed artificial limb, the amputation, when practicable, was done in the lower part of the leg. But this difficulty has been removed by the introduction of a short wooden pin, in the socket of which the stump may be fixed in the extended position ; and amputation in all admissible cases should consequently, even amongst the poorer classes, be done as low down as possible.

The number of arteries divided will depend upon the situation of the amputation. Holden lays down as a general rule in amputations one inch below the head of the fibula, one main artery only—the popliteal—is divided. At two inches two arteries, the anterior and posterior tibial, are cut. At three inches three arteries, the peroneal, in addition to the two tibials, being divided.

Flap Amputation of the Leg by Transfixion may be performed in the following way. The tourniquet having been applied to the lower part of the thigh, the Surgeon stands with his left hand to the part to be removed, while the assistant, whose duty it is to retract the flaps, takes his stand in this, as in all amputations of the lower extremities, opposite to the Surgeon. In the *left* limb, the point of the knife is entered at the posterior edge of the tibia, carried forwards for a distance of one inch and a half to two inches, then across the anterior part of the leg to the posterior border of the fibula, up which the incision is made to extend to a corresponding distance. In the *right* leg the same incision commences on the fibular side of the limb, and terminates on the tibial. The flap thus formed, which should be broad and well rounded, is next dissected up by a few touches of the point of the knife,

and transfixion of the limb is made by passing the blade across behind the bones, from one angle of the incision to the other (Fig. 70), taking care not to pass the knife accidentally between the two bones instead of behind them. The posterior flap is then formed by cutting obliquely downwards and backwards, and should be about three inches long. The bones are next cleared by a double sweep of the knife, and the interosseous soft parts divided by carrying the instrument in a figure-of-8 way between the bones. In doing this, especial care must be taken not to direct the edge upwards, so as to split either of the tibial arteries, more particularly the anterior : for, as this vessel retracts above

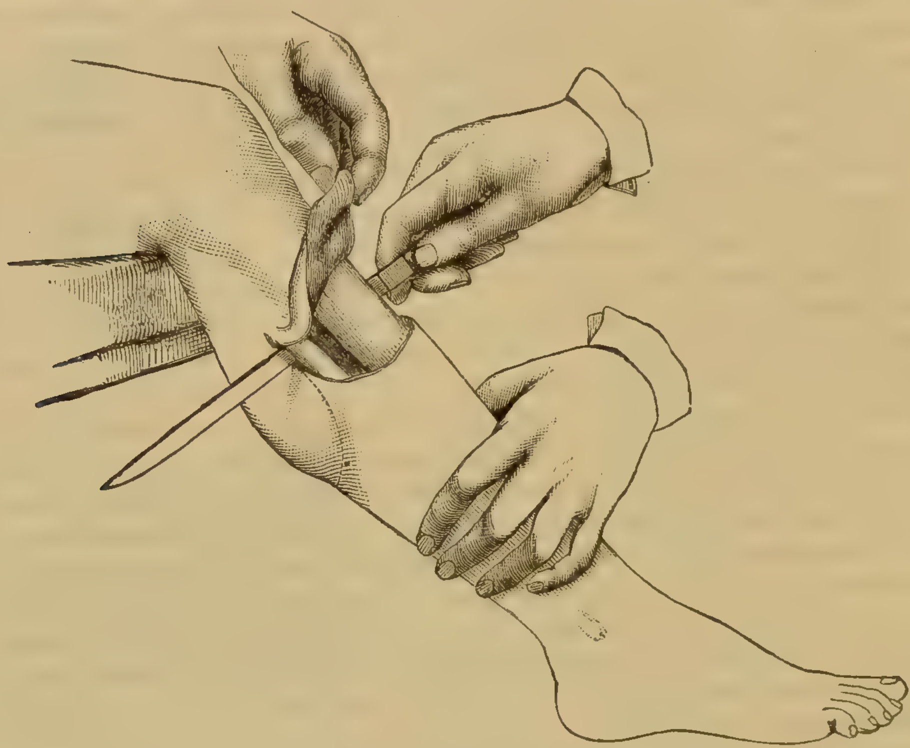


Fig. 70.—Amputation of the Right Leg. Transfixion of the Posterior Flap.

the membrane, its ligature, when divided too high, is no easy matter. If the amputation be performed just below the knee, it is possible that the popliteal trunk may be divided before its bifurcation, and thus one artery only require the ligature. In sawing the bones the fibula must be divided first, as otherwise it may be fractured above the line of amputation, or, at any rate, be splintered. It is better to commence sawing on the tibia till the saw has entered a short distance, then by sinking the hand below the level of the limb on the left side, or raising it on the right, the saw is brought to bear on the fibula, which is completely divided before the tibia is finished. After the removal of the limb, the sharp anterior edge of the tibia may advantageously be sliced off obliquely, so as to lessen the risk of sloughing of the corresponding flap from pressure upon a sharp ridge of bone.

If the limb be very muscular, a large pad of the muscles of the calf will be left in the posterior flap ; this will usually be a good deal in the way during treatment ; it may slough, and thus interfere with proper union. In some

cases, I have advantageously removed at one sweep the greater part of the muscular mass thus left, leaving little more than a skin-flap. In order to avoid redundance of muscle, the best operation consists in forming skin-

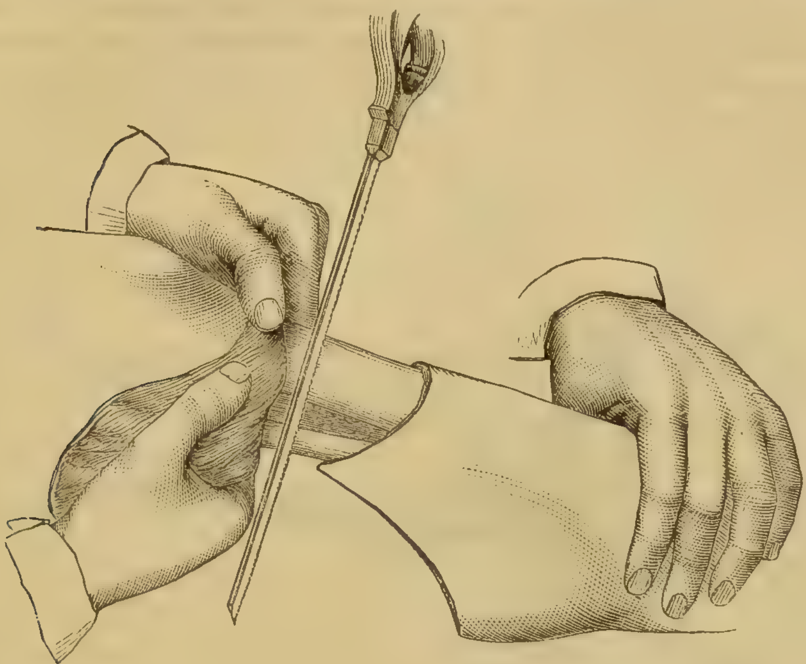


Fig. 71.—Amputation of the Leg. Sawing the Bones.

flaps on the anterior and posterior aspects of the limb, and then making a circular cut through the muscles. This may be done in various ways accord-

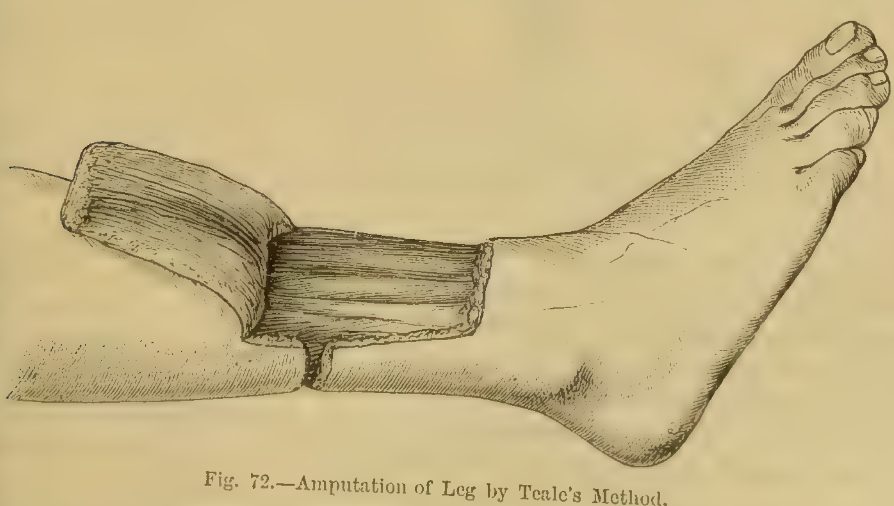


Fig. 72.—Amputation of Leg by Teale's Method.

ing to the seat of the amputation and the amount of skin available for the formation of flaps.

In cases of injury immediately above the ankle, Teale's operation (Fig. 72), can be readily performed according to the rules laid down on p. 63. If, however, the soft parts be retracted from the bones for a distance of from an inch to

an inch and a half or two inches above the angle of the flaps, all the advantages of Teale's method can be obtained by making an anterior flap equal in length to the diameter of the limb almost rectangular in shape, but having the angles rounded off. A very short posterior flap may be cut to meet this by carrying the knife behind the limb somewhat obliquely from one end of the first incision to the other. The soft parts are then retracted and the bone sawn as high as possible. As in Teale's method, the flaps should contain all that can

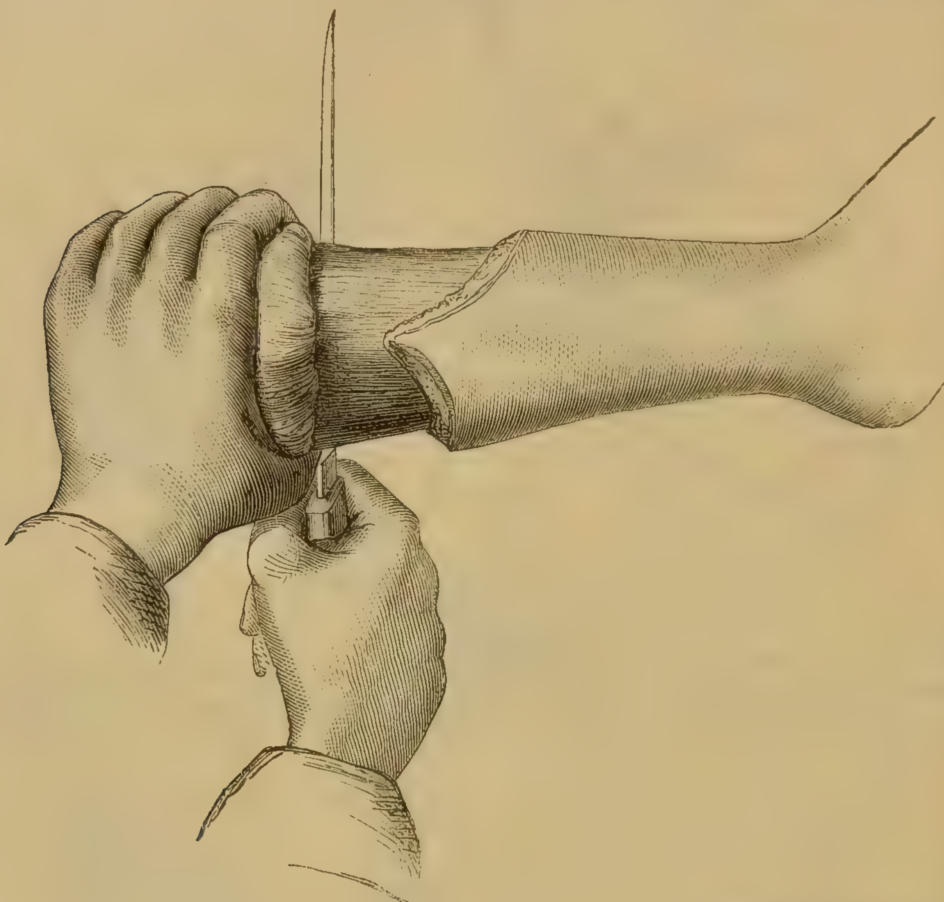


Fig. 73.—Amputation of the Leg by Long Anterior and Short Posterior Skin flaps, with Circular Division of the Muscles.

be taken from the bones, for in this situation they are somewhat liable to slough. Lister recommends that the incision should be carried, on the fibular side, as high as the point at which the bone is to be sawn, as this greatly facilitates the separation of the soft parts. In order to avoid unnecessary wounding of the anterior tibial artery, Teale recommends that the soft parts should be raised from the interosseous membrane by the finger or thumb nail.

In the middle and upper thirds of the leg, the bones lie more towards the anterior aspect of the limb, and consequently it is not necessary to provide so long an anterior flap in order that the cicatrix may be placed well behind them. In these situations the anterior flap may be made equal in length to two-thirds of the diameter of the limb, and the posterior flap one-half the length of the anterior. The anterior flap should consist, at its lower edge, of skin and fat only, but it should be gradually deepened as it is raised, till at its base it contains almost all the muscle that can be obtained from the front of the limb

(Fig. 73). In dissecting up the posterior flap, the limb should be raised so that the Surgeon can more conveniently see what he is doing. It should contain only skin and fat. Both flaps being held well out of the way, the muscles are now divided circularly, and the soft parts raised from the bones for a distance of from one and a half to two inches. In doing this, care must be taken not again to wound the anterior tibial artery. Finally, the bones are cleaned and sawn as high as possible. The sharp point of the tibia must be rounded off. In doing this it is well carefully to raise the periosteum with a knife or periosteal elevator before applying the saw or bone-forceps, as by so doing the tendency to necrosis is somewhat diminished, the periosteum not being torn away to a higher point than that at which the bone is actually sawn.

If from any cause there should not be sufficient skin available to form the long anterior flap, the **circular operation** or the modification of it recommended by Liston, as described on p. 62, may be employed instead (see Fig. 23, p. 62). All these operations have the great advantage of getting rid of the heavy mass of the muscles of the calf, and that by the long anterior flap secures in addition that the cicatrix shall be well behind the cut ends of the bones, and that there shall be a dependent opening for the exit of the discharges. The long anterior flap tends to keep itself in position by its own weight, and no strapping is required as in the amputation by the long posterior flap, and thus a great source of pain to the patient and of disturbance to the stump is avoided. The tendency to protrusion of the bone is also much less, as the weight of the flap is hardly sufficient to cause ulceration, if the end of the tibia has been carefully rounded.

Results.—Amputation of the leg is, upon the whole, a successful operation. The mortality, however, varies not only according to the situation at which the limb is removed, but also according as it is done for injury or disease, and the nature of that disease. So far as situation is concerned, it may be stated, as a general rule, that the nearer the knee the greater is the danger.

In amputation of the leg for injury, the rate of mortality is, upon the whole, rather high. In the Crimea, 37 per cent. of the cases were lost. The table at p. 82 shows an average mortality in civil practice of 46·1 per cent.; the death-rate, however, varies greatly in the records of different hospitals. Thus, at the Edinburgh and Glasgow Infirmaries, and Guy's Hospital, in an aggregate of 224 cases, there were 116 deaths; while in 353 cases in country hospitals, the number of deaths was 99, and in 66 cases at St. Bartholomew's Hospital, there were 20 deaths. At University College Hospital, the mortality has been 31·8 per cent. Secondary amputation is more fatal than primary; the deaths from the former, according to the table at p. 84, being 48, and from the latter, 43·9 per cent. After amputation of the leg for disease, the mortality is much smaller; amounting, on a calculation based on 1281 cases, to 23·5 per cent. The chief causes of death are pyæmia, gangrene of the stump, and exhaustion.

The statistics collected from published hospital reports by Max Schede, show the following results. Upper or middle third, for injury, 130 cases, 54 deaths, or 41·5 per cent.; for disease, 178 cases, 44 deaths, or 24·7 per cent.; lower third, for injury, 33 cases, 3 deaths, or 9·1 per cent.; for disease, 128 cases, 19 deaths, or 14·0 per cent.; part of leg not stated for injury, 1956 cases, 785 deaths, or 40·0 per cent.; for disease, 1695 cases, 215 deaths, or

12·7 per cent. In military practice, the French statistics show a mortality in all cases of 79·8 per cent. Excluding French cases, other military reports show a mortality of 33·1 per cent. in primary amputations, 75·0 per cent. in intermediate, and 49·7 in secondary. In the cases in which the time is not stated, chiefly from the American Civil War, the mortality was only 26·6 per cent. The combined results of Busch, Max Schede, Socin, and Volkmann, from cases treated antiseptically, excluding all those complicated by other injuries or grave disease, are as follows—for injury, 19 cases, no deaths; for disease, 50 cases, 1 death from erysipelas, to which the patient was liable. The results obtained by Bardeleben, Billroth, and Bruns, without antiseptic treatment, all complicated cases also being excluded, were : for injury, 28 cases, 15 deaths, 10 from pyæmia, and 2 from septicæmia ; for disease, 87 cases, 25 deaths, 19 from pyæmia, 5 from septicæmia, and 1 from secondary hæmorrhage.

Amputation through the Knee-joint, originally recommended in the last century by Hoin, and reintroduced by Velpeau, Markoe, and Brinton, has for some years found favour in this country and in America.

Amputation through the knee-joint may be performed in three different ways : 1, with a long posterior and a short anterior flap ; 2, with a long anterior and a short posterior flap ; 3, by lateral flaps.

1. The operation with the **Long Posterior and Short Anterior Flap** may be readily performed in the following way. An incision is made directly across the knee-joint, just below the patella. The skin-flap thus formed is dissected back ; and, the joint being opened above the patella, and the ligaments divided by a few touches of the knife, a long posterior flap is cut from the upper part of the calf of the leg, by passing the knife behind the tibia, and carrying it downwards for a suitable distance.

This operation has the great disadvantage that the posterior flap has an almost uncontrollable tendency to retract, and it should never be undertaken when the covering can be obtained more extensively or entirely from the front.

2. The operation by means of a **Long Anterior and Short Posterior Flap** is thus performed. A long square flap, rounded at the corners, is made by entering the point of a short broad-bladed amputating-knife towards the posterior part of one condyle, carrying the incision downwards in a straight line for four or five inches, then across the limb, and finally upwards to a point on the opposite side corresponding to that of entry. The integuments and the patella are then dissected from the front of the joint (Fig. 74). The articulation is thus opened ; the ligaments are then successively divided, the limb being forcibly bent ; and a posterior flap is formed by cutting with a determined sweep from behind forwards, or by dissecting down behind the bones and then cutting backwards. The flap should be about 2½ to 3 inches long. If made shorter than this, it is apt to retract up the back of the thigh. Indeed, in all cases there is a great tendency to this, even when the flap is of the length above given. The popliteal artery is divided, and, with the exception of the articular vessels, is the only one requiring ligature.

The management of the patella is an important question ; some Surgeons advocating its removal, and others its preservation. I think that it is decidedly better to leave than to remove this bone. If left, it forms an important addition and protection to the end of the stump. If it be removed, not only are these advantages lost, but the flap becomes so thinned and weakened as to incur danger of gangrene. I have practised the operation

both ways, and have from my experience found it most advantageous to leave the patella. There is only one objection to this; and that is the chance of the patella being drawn up, as occasionally happens, upon the anterior part of the thigh. This is best prevented by cutting across the tendinous insertion of the quadriceps extensor during the operation.

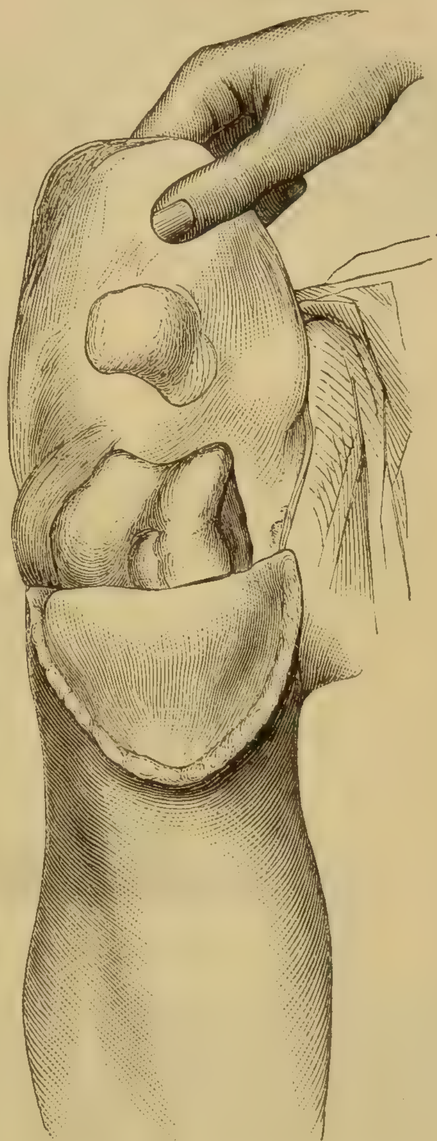


Fig. 74.—Amputation through the Knee, by Long Anterior Flap.

There is a difference of practice in the management of the cartilaginous surface of the femur in these amputations. Some Surgeons prefer leaving it; others saw it off. If the articular surface be sound, the cartilage had better be left, as thus the cancellous structure is not opened, and one predisposing cause of pyæmia is avoided. If the cartilages be eroded or otherwise diseased, they should be removed. This I generally do, after the disarticulation has been completed, by means of a fine-bladed Butcher's saw, cutting round and not across the end of the bone; thus not shortening the stump, but simply removing the cartilage, which would otherwise necrose or disintegrate, and thus interfere with ready union. If the cartilage be left on the femur, it should also be allowed to remain undisturbed on the patella. But if it be removed from the femur so as to expose the cancellous bone, then the under surface of the patella should be removed in a similar manner, before the flap is laid down. This will be found to furnish an excellent covering to the bone; the patella, and the thick, tough, and extensile integuments of the knee, forming a good basis of support for the limb to bear upon, and one well adapted for pressure. The cut surface of the patella will apply itself to, and unite with, the cancellous surfaces of the condyles, and thus add to the solidity of the end of the stump.

In the after-treatment great trouble may arise from accumulation of the discharges in the synovial pouches. This can be prevented only by proper drainage. Before closing the wound, two long tubes must be put in, in such a way that their deep extremities lie in the extreme upper parts of the synovial pouches, and their lower ends must be brought out at the angles of the wound. These tubes should not be touched till the third day; after that

they may be drawn out half an inch or more at each dressing, and the projecting piece cut off. They must on no account be completely removed in order to shorten them, as it would be impossible to replace them. Should pus form in the synovial pouches from failure of the drainage, it will be recognised by the swelling, redness and pain, with fluctuation. A free incision must be made into it as soon as the condition is recognised, or the pus may burst through the limits of the synovial pouch, and burrow up the thigh beneath the vasti. These precautions for drainage are necessary in all amputations in which the synovial pouches are opened.

3. S. Smith, of New York, amputates at the knee by **Lateral Flaps** in the following way. The incision is commenced about an inch below the tubercle

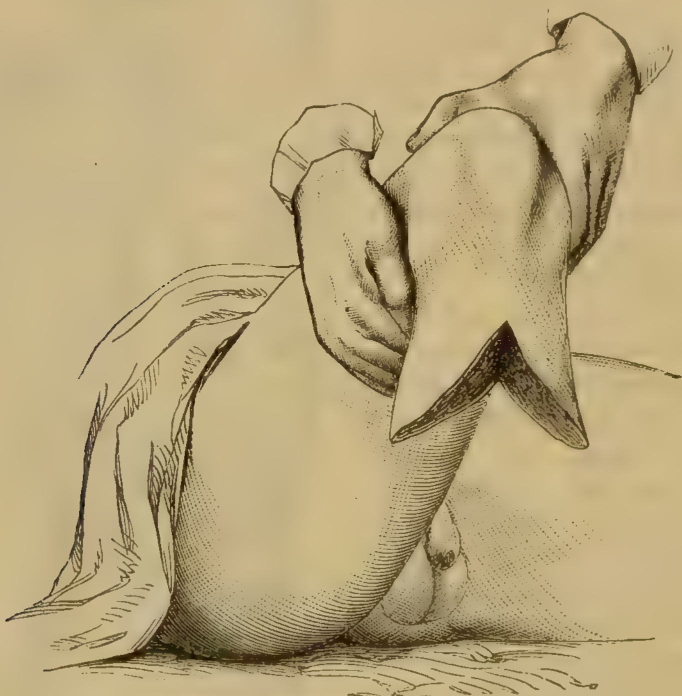


Fig. 75.—Amputation at Knee by Lateral Flap.

of the tibia, and is carried downwards and backwards over the most prominent part of the side of the leg, until it reaches the under surface, where it is directed towards the median line. When this point is reached, it is carried directly upwards to the centre of the popliteal space. A second incision begins at the same point as the first, and pursues a similar direction on the opposite side of the limb ; the two incisions meeting in the median line behind. The flaps are then raised, the joint opened, and the leg removed. The inner flap should be rather the larger ; and the patella is left. After this amputation, the stump presents the appearance represented in Fig. 75.

Amputation through the Condyles may be done by a long posterior or a long anterior flap, including the patella or not ; or by a modification of the circular method. Of these, that by the long posterior flap should never be employed, unless, from exceptional circumstances, no other flap can be obtained. Carden of Worcester was the first to employ the method of amputation by the long anterior flap in this situation. He took away the patella and made no posterior flap, but subsequent operators have found that without a posterior flap the covering is frequently insufficient. The operation is therefore usually performed

as follows. The finger and thumb of the left hand are placed on the two condyloid eminences of the femur, which serve as guides for the starting points of the incision. A long anterior flap is then marked out, well rounded in shape, and reaching as low as the tuberosity of the tibia. This is dissected up either with or without the patella. In cases in which the Surgeon is hesitating between excision and amputation, the joint may be examined before proceeding further and the operation determined on. When the anterior flap has been raised, the knife is passed behind the femur, and a posterior flap, equal in length to the anterior, is cut from within outwards. This flap contains the hamstring tendons, and usually a part of the muscles of the calf, and it consequently retracts considerably after being cut. The flaps being held back, the knife is swept round immediately above the cartilage-covered surfaces, and the saw carried through the bases of the condyles parallel to the articular surface

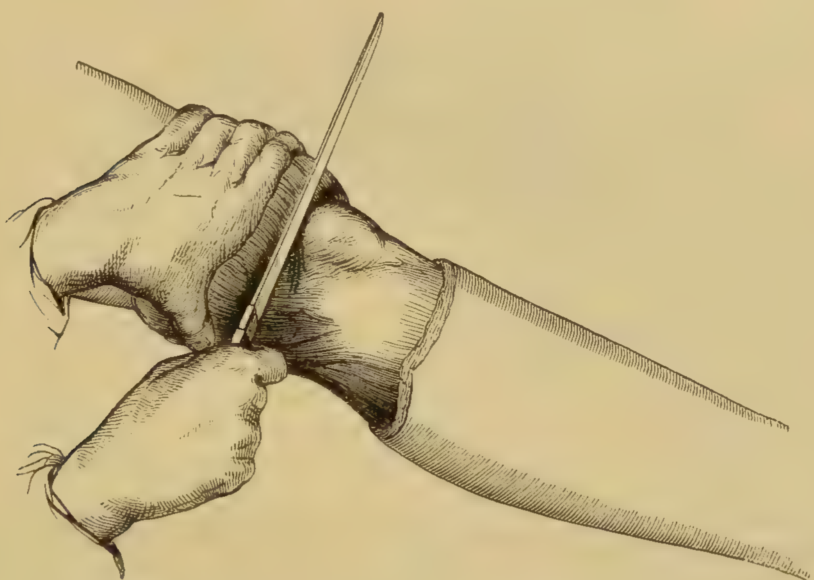


Fig. 76.—Amputation through the Condyles by modified circular method.

of the femur, that is to say, somewhat obliquely to the axis of the shaft, the inner side being left a little longer than the outer. Gritti, an Italian Surgeon, and Stokes of Dublin have recommended that the patella should be left in the flap, and its cartilaginous surface sawn off so as to form a raw bony surface to be applied to the cut end of the femur.

As a modification of these operations, Lister has recommended an amputation by a modified circular method, which is thus performed. "The Surgeon first cuts transversely across the front of the limb, from side to side, at the level of the anterior tuberosity of the tibia, and joins the horns of this incision by carrying the knife at an angle of forty-five degrees to the axis of the leg through the skin and fat. The limb being elevated, he dissects up the posterior skin flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue; and, dividing the hamstrings as soon as they are exposed, and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks the knife through the insertion of the quadriceps extensor (Fig. 76), and, having cleared the bone immediately above the articular cartilage and

holding the limb horizontally, he applies the saw vertically and at the same time transversely to the axis of the limb (not of the bone) so as to ensure a horizontal surface for the patient to rest on." When the soft parts are much thickened, as in disease of the knee-joint, the patella may be raised in the flap and the leg removed by cutting the crucial and lateral ligaments. No great difficulty will then be found in exposing and sawing off the condyles of the femur, and the patella may then be removed last of all. The advantage of this operation is that if it be carefully performed, the chance of sloughing is reduced to a minimum. The pouches of the synovial membrane of the knee must be carefully drained as before described.

There is a point of practice that I have found useful in these amputations; viz. to round off with the saw the sharp edge left on the condyle after the removal of its cartilaginous surface, as otherwise this may press injuriously upon the flap. In the after-treatment, the patella, if present, should be kept in its place by a strip of plaster well brought down above it.

These amputations present four great advantages over those higher up. 1. As the medullary canal of the femur is not opened, the patient is saved all that risk which results from suppuration within that canal, and the consequent liability to suppurative inflammation of the veins of the bone, and consecutive pyæmia. 2. The limb being removed at a greater distance from the trunk, the shock will be less and the rate of mortality diminished. 3. The patient is provided with a long thigh-stump, which gives increased leverage in using an artificial limb. 4. When the amputation is practised with the long anterior flap containing the patella, or taking the skin from over it, the end of the stump will be protected by the dense and tough integumental and aponeurotic structures naturally situated in front of the knee-joint, which admit of pressure being made upon them without fear of excoriation: the cicatrix being drawn up behind the end of the stump, and altogether away from its surface.

Results of Amputation through the Knee-joint or Condyles of the Femur.—So far as life is concerned, these operations have been successful. In the war of the American rebellion, of 132 cases, 64 died, giving a mortality of 48·4 per cent. Of these 49 were primary amputations; the deaths among which were 16, or 22·6 per cent. Brinton gives 62 cases of amputation through the knee for disease, with 14 deaths, or 32·6 per cent. The statistics of amputation through the condyles of the femur as distinguished from amputations through the knee have not been made out.

Max Schede gives the results of amputation through the knee-joint in civil practice as follows: for injury, 314 cases, 103 deaths, or 32·8 per cent.; for disease, 123 cases, 30 deaths, or 24·4 per cent.; through the condyles, for injury, 111 cases, 40 deaths, or 36·1 per cent.; for disease, 60 cases, 15 deaths, or 25 per cent.; Gritti's operation, for injury, 25 cases, 4 deaths or 16 per cent.; for disease, 19 cases, 5 deaths, or 26·3 per cent.

Amputations of the Thigh are commonly required both for accident and for disease. They may be performed immediately above the knee, in the middle of the limb, or in its upper third. Amputation just above the knee may be done by lateral flaps, the mass of muscle in this part of the thigh lies on each side of the limb, the central portion being occupied in front by the tendinous and aponeurotic structures connected with the patella, and behind by the upper triangle of the popliteal space: hence, if antero-pos-

terior flaps be made here, they will be thin and tendinous in the middle; whereas the lateral flaps are uniformly thick. Lateral flaps have, however, the disadvantage of leaving the scar over the bone, and they are more difficult to keep in position than antero-posterior flaps, consequently many Surgeons prefer the latter. In the middle and upper thirds of the thigh, the soft parts are so distributed that the antero-posterior flaps always leave the best result, and give the best covering to the bone. If lateral flaps be made in these situations, the end of the bone is apt to be drawn up into the angle of the wound between the flaps, which fall away behind it. In amputation in the lower or middle third, a tourniquet may be applied high on the limb; but when the operation is done in the upper third, there is no space

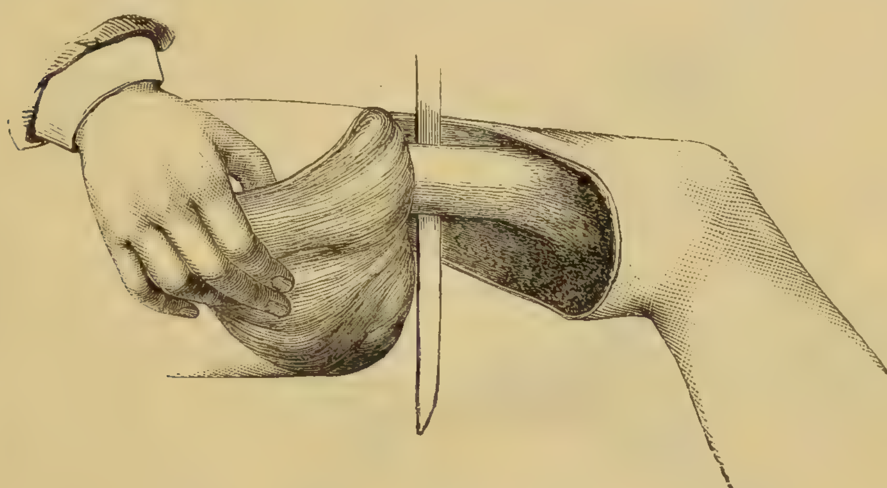


Fig. 77.—Amputation of the Lower Third of the Thigh by Lateral Flaps.

for the application of this instrument, so the hæmorrhage must be arrested by the application of the india-rubber bandage as described on p. 43, by the aortic tourniquet, or by an assistant compressing the artery as it passes over the brim of the pelvis (Fig. 18, p. 49). In whatever situation the Surgeon amputates, he must be careful to carry the knife so as not to split the femoral artery or vein.

Amputation above the Knee by Lateral Flaps, or Vermale's Operation, is thus performed: the outer flap should always be made first. The point of the knife, being entered in the middle of the thigh, about three inches above the upper border of the patella, is carried close round the bone and brought out through the centre of the ham; the flap is then cut downwards and outwards; the knife, being entered again in the upper angle of the incision, is carried close round the bone to its inner side, and the inner flap made by a sweeping cut (Fig. 77). Unless the blade be kept in contact with the bone in this situation, the femoral artery is very apt to be split. The flaps being then retracted, the bone is cleared by two sweeps of the knife, and sawn about four inches above its articular surface.

In the *Middle or Upper Third of the Thigh*, the **Antero-posterior Flap-Operation** is to be preferred. In ordinary cases, the anterior flap may first be made, and the posterior one subsequently fashioned, both by transfixion (Fig. 22, p. 57). If, however, the patient be very much emaciated, it is difficult to get a good cushion from the anterior part of the thigh in this way;

and it is consequently preferable to follow the plan recommended by Mr. Luke of making the posterior flap first by transfixion, and the anterior one afterwards by cutting from without inwards (Fig. 22). In some instances in which the tissues at the posterior part of the thigh are much diseased or injured, whilst those on the anterior aspect of the limb are sound, a very good stump may be fashioned by making a long square anterior flap by transfixion, and then cutting at one stroke of the knife through the soft parts at the posterior aspect of the limb, in a somewhat oblique direction from below upwards. The anterior flap, when laid down, will form the cushion at the end of the stump.

In the great majority of cases, however, the operation will be better per-

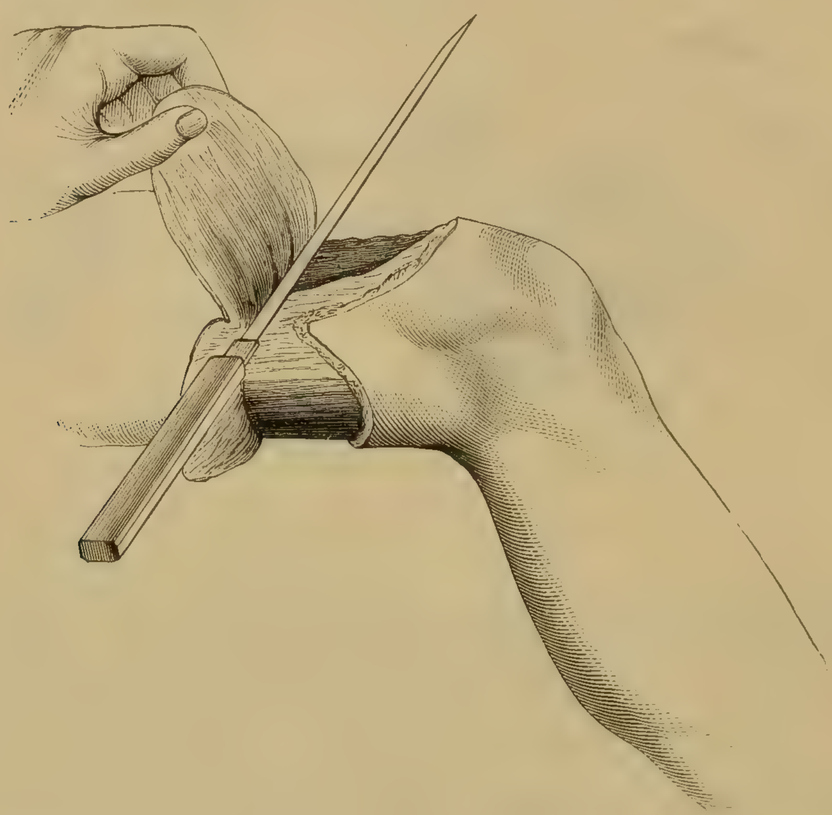


Fig. 78.—Amputation of the Thigh, Flaps cut from without inwards.

formed as follows. The Surgeon, standing on the right side of the patient, enters the knife mid-way between the anterior and posterior surfaces of the thigh on the side opposite to himself, and marks out a rectangular flap, with the right angles rounded off, equal in length to two-thirds of the diameter of the limb at the point at which the bone is to be sawn. He next sweeps the knife round the back of the thigh, so as to mark out a rounded flap half the length of the anterior flap. The limb is now raised, and the posterior flap, consisting of skin and fat only, is dissected up to the angle of the flaps, so as to free it from the ham-string muscles, and thus to limit its retraction. The anterior is now raised, only skin and fat being taken for the first inch or so, after which the Surgeon takes as much muscle as he thinks advisable to ensure the vitality of the flap (Fig. 78). The remaining muscular tissue is now

divided circularly, and the soft parts retracted for a distance of about two inches, and the bone sawn at that point. The retraction is greatly facilitated by raising the limb to a right angle with the table, as recommended by Spence. The results of this operation are most satisfactory. It may be performed equally well at any part of the thigh from the trochanters to the lower end, where the skin of the patella is included in the anterior flap.

In all amputations of the thigh more or less trouble arises from the contraction of the flexor muscles tending to displace the posterior flap upwards, and so to leave a gaping wound behind to heal by granulation. This is aggravated by the flexed position in which the patient invariably places the limb. The amount of covering should therefore never be less than twice the diameter of the limb at the point at which the bone is sawn. Thus, suppose the antero-posterior diameter to be four inches, the anterior flap should be $2\frac{2}{3}$ inches long and the posterior $1\frac{1}{3}$ in., and the muscles should be retracted for two inches. If there is sufficient skin to be had in a primary amputation it might perhaps be better even still further to lengthen the posterior flap, making it equal to the anterior.

Amputation of the thigh may be performed also by the pure circular, or the modified circular, method, both of which give excellent results in very fleshy thighs.

Amputation through the Trochanters may sometimes be advantageously practised, either in severe compound fractures of the lower part of the thigh, or in cases of non-malignant tumours of the lower and middle thirds of the femur ; and thus the more severe and dangerous operation of disarticulation at the hip may be avoided. Indeed, should it be found, after section of the bone, that it is so much injured or diseased as to require removal at the joint, this may readily enough be done by dissecting the head out of the acetabulum with a strong scalpel or bistoury.

Results.—The mortality after amputation of the thigh is very considerable when the operation is done for injury, more particularly for compound fracture of the femur itself. The mortality after amputation for injury in civil hospitals amounts, according to the table at page 84, to 59·7 per cent. In the French army in the Crimea, and in Italy, it was very high, amounting to 92 per cent. In some hospitals primary amputation of the thigh seems to have been almost invariably a fatal procedure ; whilst in other institutions the mortality has not exceeded 50 or 60 per cent. At Guy's Hospital and at University College, secondary amputation of the thigh has been more fatal than the primary.

The result of amputation of the thigh for disease of the knee-joint depends entirely upon whether the affection is acute or chronic. In acute suppurative disorganisation of the knee, amputation of the thigh is most fatal ; indeed, so high is the rate of mortality, that it is doubtful whether it is proper to perform the operation in that stage of the affection. In chronic knee-joint disease, on the other hand, the operation is most satisfactory and successful ; death seldom resulting unless the operation has been deferred too long. The general percentage of mortality after amputation for disease is about 32·5.

The causes of death vary according to the condition for which the operation is performed. In primary amputation, the fatal event is brought about chiefly by exhaustion, traumatic gangrene of the stump, or secondary hæmorrhage.

In secondary amputations, and in those for disease, pyæmia, erysipelas, and exhaustion are the usual causes of death.

Max Schede gives the following statistics for civil practice :—Upper third for injury, 78 cases, 57 deaths, or 78·0 per cent. ; for disease, 42 cases, 15 deaths, or 35·7 per cent. ; middle third, for injury, 67 cases, 50 deaths, or 74 per cent. ; for disease, 137 cases, 55 deaths, or 40·1 per cent. ; lower third, for injury, 147 cases, 74 deaths, or 50 per cent. ; for disease, 205 cases, 64 deaths, or 31·2 per cent. The military statistics (excluding the French cases) for all amputations of the thigh show the following results. Primary, 23·9 per cent. of deaths ; intermediate, 72 per cent. ; secondary, 69·6 per cent. ; time not stated, 84·9 per cent. The combined statistics of Busch, Socin, Schede, and Volkmann of cases treated antiseptically, excluding all complicated cases, are as follows :—For injury, 23 cases, 5 deaths : 3 from shock, 1 from tetanus, and 1 from septicæmia. For disease, 63 cases, 1 death from secondary hæmorrhage. Those of Bardeleben, Billroth, and Bruns, from the pre-antiseptic period, all complicated cases being excluded, are : for injury, 24 cases, 14 deaths—6 from pyæmia, 5 from septicæmia, 1 from exhaustion, and 2 from shock ; for disease, 81 cases, 29 deaths—20 from pyæmia, 1 from exhaustion, 4 from septicæmia, 1 from secondary hæmorrhage, and 3 from unknown causes.

Amputation at the Hip-joint.—This formidable operation is of comparatively recent introduction into surgery. During the early part and middle of the past century, its practicability was warmly canvassed in France. It was performed on animals experimentally. It was found that patients affected with ergotism, whose lower extremities had become gangrenous, and had separated at the hip-joint, survived ; and, at last, in the year 1773, the first successful amputation of the kind was performed by Perrault of St. Maure. In the next year, the operation was done in England by Kerr of Northampton, on a girl aged 12, affected with hip-disease and lumbar abscess. The operation was unjustifiable in such a case, but the patient lived 17 days, and thus its practicability was demonstrated. Larrey performed it in 1793 for the first time for gun-shot injury ; and since that time the operation has become an established one in surgical practice, civil as well as military. The operation was first performed successfully in England in 1812, by Brownrigg, of Plymouth, on a man whose thigh had been broken in the Peninsular war a year previously.

Amputation at the hip-joint may be and has been performed in a variety of ways, which it is not necessary to detail. The most convenient operations are those by *antero-posterior flaps*, and the *oval method*. Of these, that by **antero-posterior flaps** is the easier and more speedy. It consists in making a large and thick anterior flap by transfixion, and a short posterior one from the gluteal region and back part of the thigh. In order to perform this operation properly, the patient's body must be brought well forward upon the edge of the table, so that the nates project beyond it, and be steadied by strong bandages. One of these must be passed between the sound thigh and the perinæum, and attached to the upper end of the table ; another should be carried across the pelvis to the lower end ; and the sound limb must be tied to the leg of the table. The circulation through the limb should then be arrested by one of the means described on pp. 43, 47, so as to completely restrain the circulation through the lower extremities, thus depriving the operation of its

great danger—undue loss of blood—and enabling the Surgeon to complete it without hurry or anxiety on this account.

The Surgeon must have three assistants on whom he can fully rely. Assistant No. 1 takes charge of the flap, compressing the femoral vessels ; and, in the absence of the abdominal compressor, on his trustworthiness the patient's life is mainly dependent. Assistant No. 2 takes charge of the limb ; flexing it slightly on the abdomen in the first stage of the operation, whilst the anterior flap is being made ; forcibly abducting, extending, and rotating outwards during the second stage, when the Surgeon is opening the capsule of the joint ; and rotating inwards during the time the posterior flap is being cut. On the way in which he performs these duties, the facility with which the Surgeon performs the operation is mainly dependent. To Assistant No. 3 is

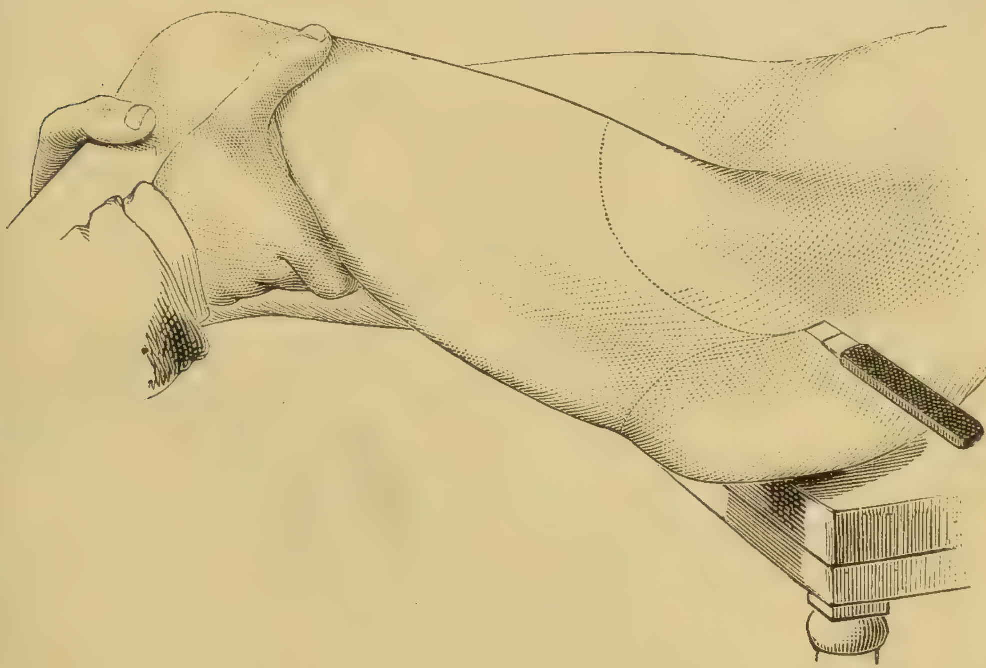


Fig. 79.—Amputation at the Hip-joint : Formation of Anterior Flap in Left Limb.

consigned the care of the compressor of the abdominal aorta. After the removal of the limb, Assistant No. 2 aids the Surgeon in ligaturing the arteries. These preliminaries having been arranged, and the duty of each assistant assigned to, and distinctly understood by him, the operation is to be performed in the following way.

The Surgeon, standing on the left side of the limb to be removed, feels for the bony points which guide his knife, viz., the tuber ischii and the anterior superior spine of the ilium. The knife, which must have a blade twelve inches long, requires to be entered, and the flap to be made, in different ways, according to the side of the body on which the operation is performed. If it be on the *left* side, the knife should be entered about two fingers' breadth below the anterior superior spine of the ilium, and carried deeply in the limb behind the vessels, directly across the joint ; its point being made to issue near the tuberosity of the ischium well behind the prominent ridge formed by the tendon of the adductor longus (Fig. 79). In transfixing on this side, care must be taken not to wound the scrotum or the opposite thigh ; the back of

the knife must run parallel to Poupart's ligament, and the point must not be held too high, lest it enter the abdominal cavity. The anterior flap must then be rapidly cut downwards and forwards, about six or eight inches in length. In doing this, care must be taken not to make the flap pointed. This is best done by keeping the edge of the knife turned slightly towards the bone till the point is reached at which it is to be brought out. Also, the assistant who holds the limb must take care not to extend it too soon, but to keep it flexed and slightly adducted until the anterior flap is completely cut; and the assistant who has charge of the flap must be careful not to raise it up too much nor to squeeze it laterally in grasping the vessel. The limb, which has so far been raised and slightly flexed upon the abdomen and adducted, must now be forcibly extended, abducted, and rotated outwards; the capsule of the joint is then to be opened by a firm cut with the point of the knife. So soon

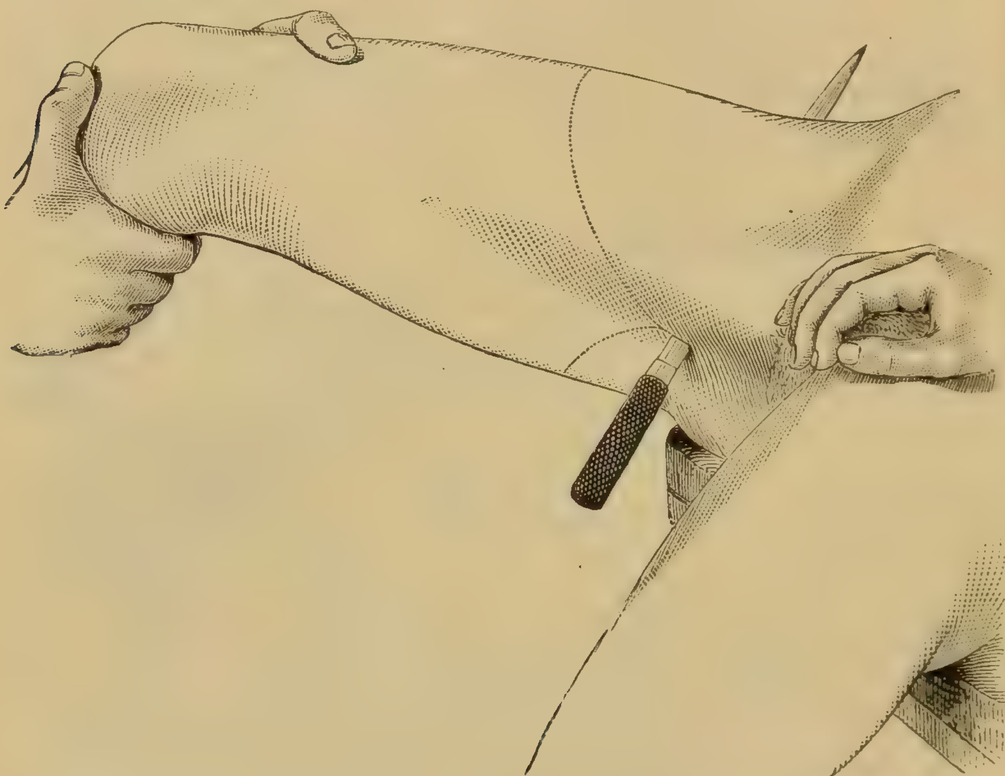


Fig. 80.—Amputation at the Hip-joint: Formation of Anterior Flap in Right Limb.

as this is done, the head of the femur starts out of the socket and the operator touches the round ligament with the point of the knife. The assistant now allows the limb to hang down, and the head of the femur becomes separated by some distance from the acetabulum, and the posterior part of the capsule is brought into view and put on the stretch. This is divided with the point of the knife, and immediately it is done the assistant puts the limb in an extended position in a line with the body, and at the same time rotates it inwards so that the trochanter shall not catch the knife; the heel of the knife is then passed over the trochanter, and the posterior flap rapidly cut by carrying the knife downwards and backwards through the thick muscles in this situation. The posterior flap may be about four inches in length; but

this must of course vary according to the length of the anterior flap. When the amputation is performed on the *right* side, the anterior flap is made by entering the knife just above the tuberosity of the ischium, and bringing it out two fingers' breadth below the anterior superior spine of the ilium (Fig. 80); the remaining steps of the operation being performed as in the last case. In transfixing from the inner side, if the point of the knife be directed too much upwards, it may enter the thyroid foramen.

In order to avoid the inconvenience caused by standing in a cramped position between the patient's thighs, many Surgeons transfix from the outer side on the right side as well as on the left.

In consequence of the extent to which the limb that is about to be removed may have been injured, or have been encroached upon by disease, it is not always easy to make the anterior flap of the size or shape described. A little management on the part of the Surgeon will however enable him to take the requisite amount of covering from the outer or inner parts, by inclining the point or the heel of the knife downwards, as the case may require; or he may make the anterior flap by incision from without inwards, instead of by transfixion.

When the femur is entire and unbroken, Assistant No. 2 uses it as a lever, bringing the lower end of it in the second stage of the operation downwards and outwards, thus causing the head of the bone to press against the anterior part of the capsule, and to start out with a peculiar sucking noise as soon as the latter is opened. Should, however, the bone have been fractured high up, this movement cannot be given to it; and then the Surgeon must grasp the upper end of the femur below the trochanters, so as to steady and push it back as he is disarticulating its head. In two of the cases in which I have amputated at the hip-joint, it has been necessary to do this—in one, in consequence of the crush of the bone, two inches below the trochanters, by a railway accident; in the other, in consequence of its spontaneous fracture at the junction of its upper and middle thirds, in a case of rapidly growing malignant disease of the bone. This fractured condition of the femur necessarily makes the operation somewhat more difficult, as the Surgeon is deprived of the long lever afforded by the limb in its sound state, by which the head is tilted upwards and forwards, and the capsule put on the stretch so as to be brought directly against the point of the knife as it is drawn across it.

In amputation at the hip-joint, the great immediate danger formerly apprehended was excessive hæmorrhage, the incisions being made so high up that no ordinary tourniquet could be applied. By means of Pancoast's compressor, the circulation through the abdominal aorta may be arrested, and thus the danger has been obviated. Even now the arrest of the hæmorrhage during the operation must be intrusted to an assistant who can be fully relied on. After the abdominal compressor has been applied, and the flow of blood through the aorta arrested, his business should be to compress the artery above the brim of the pelvis, and then to follow the knife in the first incision, and, as the anterior flap is being made, slip his fingers under it and grasp it firmly above and below, so as to compress the femoral artery in it, which is divided as the knife cuts its way out (Fig. 81). By grasping the flap tightly, there will be but little risk of hæmorrhage from the femoral artery, even when the abdominal aorta has not been compressed by the application of the tourni-

quet ; but lest this should slip, or the assistant whose duty it is to grasp the flap by any chance should fail in holding it properly, it may be well to direct one of the assistants, whose business it is to steady the trunk, to have his thumb well pressed down into the iliac fossa, so as to compress the artery against the brim of the pelvis. As the posterior flap is being made, the bleeding from the gluteal and sciatic vessels, which is often very free, may be arrested by two assistants who should be ready to cover and compress them with the fingers or dry sponges, or seize them in Sir Spencer Wells's forceps. The arteries may then be ligatured one by one, as the assistant exposes them. If the other assistant have a good hold of the femoral, the vessels in the posterior flap may be tied first ; but if the femoral be insecurely held, it must be first tied. The femoral arteries, both superficial and deep, will be found to be cut long, and to project from the muscles, by which they

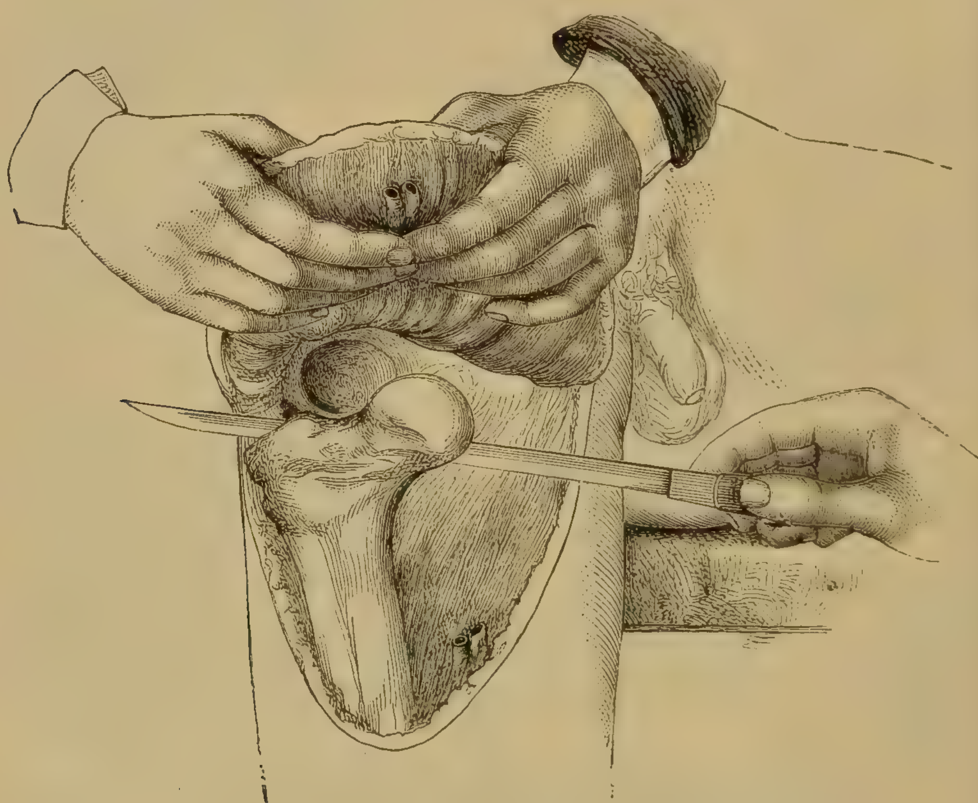


Fig. 81.—Amputation at Hip-joint : Compression of Femoral Artery in Anterior Flap.

are surrounded, so as very readily to be seized by the fingers or forceps, pulled out, and ligatured. The arteries in the posterior flap and on the inner side of the joint will be found in the inter-muscular septa. The flaps are to be brought together by six or eight sutures, and a turn of a broad bandage may then be passed round the abdomen, and the end brought up from behind under the stump so as to support them.

In former times it was of great importance to perform the operation with as much rapidity as possible, and the disarticulation was usually effected in from thirty to forty seconds, and frequently in even less time ; but since the means of arresting hæmorrhage have been perfected, time is of less import-

ance, and consequently the *oval method*, which presents many advantages, has been much more frequently practised of late years.

The oval amputation is performed in a variety of ways, and more experience is, perhaps, still required to determine which is the best. The following plan has been found to answer well at University College Hospital. The patient is to be placed on his sound side, and the thigh of that side is to be flexed as far as possible and secured in that position by two bandages, one attached to the thigh immediately above the knee with a clove hitch, the two ends of which are passed round the patient's neck and under the arm of the same side and firmly knotted together. This bandage maintains the flexed position of the thigh, which gives steadiness to the trunk. The second bandage is to be passed also round the sound thigh and secured to the leg of the table beneath the patient's head, in order to prevent his slipping down during the operation. The patient's body must be further steadied by an assistant placed opposite the shoulders. Another assistant takes charge of the thigh, and a third, who stands opposite the Surgeon, will take the vessel by thrusting the fingers of one hand into the wound and grasping the artery between them and his thumb. The patient being thus prepared, and the india-rubber band or aortic clamp applied, the Surgeon stands so as to have his left hand to the flaps, that is to say, behind for the right thigh, and in front for the left. An amputating knife of moderate length is to be chosen. In operating on the right side the incision is commenced about two inches above the trochanter and carried firmly down to the bone and along the femur to about six or seven inches below the upper end of the bone. At this point the incision is made to bifurcate, one part being carried in a curved direction forwards for about two inches and the other backwards in the same way. This marks the point at which the transverse part of the incision is to be made. The limb is now abducted, and, if the first incision has been made with sufficient firmness, the operator will be able to push his thumb into the longitudinal slit which has been made in the lower parts of the two smaller glutei. The muscles thus being put on the stretch, the point of the knife is made to cut over the trochanter and down the upper part of the bone, completely separating the muscles attached to it, first in front and then behind. The limb is then forcibly adducted, and the assistant at the same time tries to lift the head of the femur out by putting one of his hands on the inner side of the thigh as high up as possible. The operator then opens the joint by making a firm cut in the line of the superficial incision, so as to make a slit in the capsule and to divide the cotyloid ligament, and thus to render dislocation more easy. Another incision is then carried backwards in the capsule in the line of its attachment. The head of the bone then starts from the socket and the point of the knife is inserted so as to divide the round ligament. If the head does not come out readily, the assistant may seize the exposed trochanter with a pair of lion forceps and drag it forcibly outwards. The remainder of the capsule is then cut, and the assistant can now lay hold of the trochanter and pull it forcibly out of the wound, while the operator, getting his knife to the inner side while he holds the soft parts out of the way with his left hand, gradually separates the bone from its attachments till it is exposed as low as is required. During this part of the operation the limb must still be adducted to the greatest possible extent. Having reached the point at which the commencement of the transverse part of the

incision has been already marked, the Surgeon turns the edge of the knife away from the bone and cuts across to the inner side of the limb, thus completing the amputation. During this part of the operation the assistant must bring the limb into a straight line with the trunk. The artery must be compressed by an assistant with one hand in the upper part of the wound. In operating on the left side, the first incision is made from below upwards. In other respects the operation is performed in the same way as on the right side. If the limb be very muscular it is a good plan, after having enucleated the upper part of the femur, to complete the circular part of the incision by cutting from without inwards, carrying the incision only through the skin and fat, which may then be turned up for a couple of inches, the muscles being divided last of all at the higher level. The wound must be carefully united with sutures, a large drainage tube being inserted at the outer side. The advantages of the oval method are: firstly, as pointed out by Furneaux Jordan, it leaves a smaller wound than the flap amputation, and, secondly, it can more easily be dressed by some of the antiseptic methods, as there is an interval of six or seven inches at the inner side of the stump between the wound and the anus. The only disadvantage it presents is, that it is more difficult and tedious of performance.

In order still further to diminish the size of the wound, some Surgeons have recommended that the thigh be amputated immediately below the trochanters, first, and the upper part of the femur be then excised from the wound.

Results.—The mortality after amputation at the hip-joint is necessarily very high. This we should naturally expect from the size of the part removed and the consequent shock to the system. The rate of recovery varies greatly according to the condition of the limb that necessitates the operation. Thus, amputation at the hip-joint had been performed, so far as I could ascertain from published cases, 126 times up to the year 1864; of these 76 died. In 47 instances it was for injury: of these 35 proved fatal; whilst in 42 cases in which it was done for chronic disease, 24 recovered and only 18 died.

Primary amputation at the hip-joint in cases of severe injury of the thigh, by gunshot or otherwise, with comminution of the femur, is one of the most fatal operations in surgery. In all the 12 cases in which it was done in the Crimea it proved fatal; and Legouest has collected 30 cases of this amputation for gunshot injury, in all of which the operation terminated in death. Indeed, up to the time of the war of the rebellion in America, there was no authentic instance of recovery under these circumstances. But in the elaborate and most able surgical history of that great war, published by the Surgeon-General, 19 cases of primary amputation at the hip-joint for gunshot injury of the femur are related. Of these 11 died from the immediate shock of the operation; 5 died between the 2nd and the 10th day; one, a man 28 years of age, who had amputation at the hip performed by Surgeon Shippen seven hours after the receipt of his wound, was in perfect health four years after the operation; and the remaining two cases had been cured, so that one was alive and well two, and the other six, months after the amputation.

Intermediate operations, or those done during the inflammatory period, are very unsuccessful: 18 cases that occurred in the American war were all fatal.

Secondary amputation, in cases of attempted preservation of the limb after severe injuries and gunshot-wounds, has been far more successful. Four cases

in which J. Roux practised it in the French campaign of 1859 in Italy all recovered, as did two out of nine in which it was practised in America.

Re-amputation at the hip-joint for diseased thigh-stumps has also been a successful operation : 4 out of 7 American cases recovered.

Amputation at the hip-joint for disease of the femur has undoubtedly become less fatal of late years than formerly. This is owing to the operation being submitted to at an earlier stage of the disease ; to a better selection of cases ; possibly to improved methods of after-treatment ; but mainly to the influence of anæsthetics, by which the shock to the system necessarily resulting from so very severe a mutilation is materially lessened. The employment of Pancoast's aorta-compressor and the elastic band will probably still further reduce the mortality by lessening the loss of blood.

The more extended statistics lately published by Max Schede show the following results :—Amputations in civil practice,—for injury, 55 cases, with 39 deaths, or 70·90 per cent. ; for disease, 153 cases, 65 deaths, or 42·68 per cent. The carefully collected statistics of Lüning of amputations for gunshot wounds show the following results : primary amputations—90 cases, 84 deaths, or 93·33 per cent. ; intermediate amputations (from second to fourth day)—22 cases, 21 deaths, or 95·45 per cent. ; secondary or late amputations—53 cases, 42 deaths, or 79·24 per cent. ; amputations in which the date is not stated—65 cases, 60 deaths, or 92·30 per cent.

CHAPTER IV.

LOCAL DISTURBANCES OF CIRCULATION, AND INFLAMMATION.

Local Disturbances of Circulation.—These may be of three kinds, Local Anæmia; Active Hyperæmia, Active Congestion, or Determination of Blood; and Passive Hyperæmia or Passive Congestion.

LOCAL ANÆMIA.

Local Anæmia may be complete and permanent, as in obliteration of the arteries leading to a part by the formation of a clot of blood within them, by disease of their coats, by pressure from without, or from a wound. Complete anæmia may result also from diffused pressure acting on the capillaries. This condition must necessarily lead to the death of the affected part, and will be considered when treating of gangrene. It may also be incomplete and permanent from the same causes acting in a less degree. Whenever from any cause the arteries leading to a part are permanently diminished in calibre, the amount of blood circulating through the area supplied by them must necessarily be diminished, and the tissues will suffer in proportion to the diminution. Such a condition is very common, as we shall afterwards see, from degenerative changes in the coats of the arteries in old people. Under such circumstances the nutrition of the part is impaired. It is colder and paler than natural, the growth of the epithelium is imperfect, and the surface is often dry and scaly; in a limb, the nails are brittle and grow more slowly than natural; the muscles are weak and are liable to irregular painful contractions or cramp. The power of resistance to external injuries is lessened: a slight degree of cold causes gangrene; wounds tend to slough and ulceration to occur in the skin from superficial abrasions; and inflammation in general arises from causes that would be harmless to a healthy part, and tends readily to assume a spreading form and to terminate in suppuration or gangrene. Permanent local anæmia acts therefore as one of the most important predisposing causes of inflammation. Temporary local anæmia may be produced intentionally by the surgeon, as in the bloodless methods of operating already described, or by pressure applied to arrest bleeding. Physiologically it is produced by contraction of the muscular fibre cells in the middle coat of the arteries. This may be brought about by direct stimulation of the artery, such as occurs from mechanical injury, cold or exposure in a wound, or through the medium of the vaso-motor nerves. Stimulation of the sympathetic nerves, either direct or reflex, causes temporary contraction of the vessels in the area supplied by the nerves to which the stimulus is applied. As familiar examples of local anæmia from contraction of the arteries, we may take the dead-white colour of fingers or toes from exposure to cold, and the anæmia of the brain with insensibility which forms the condition known as concussion after a blow

upon the head. Local anæmia of one part may result also from hyperæmia of another, as the amount of blood in the body is not nearly sufficient to distend all the vessels fully. The most familiar example of this is the faintness from anæmia of the brain which results from immersing the body in a hot bath, by which the whole of the cutaneous vessels become widely dilated, thus more or less draining the internal parts. In whatever way temporary local anæmia is produced, as soon as the cause is removed it ceases, and is replaced by hyperæmia, varying in intensity with the duration and degree of the previous anæmia. Familiar examples of this are: the red glow that succeeds when the fingers recover after having been "dead" with cold, and the blush and oozing of blood that follows the removal of the tourniquet in bloodless methods of operating.

ACTIVE LOCAL HYPERÆMIA, ACTIVE CONGESTION, DETERMINATION OF BLOOD, OR FLUXION.

This condition consists essentially of an increased flow of blood to a part, owing to a dilatation of the arteries from relaxation of the muscular fibre-cells of the middle coat. The term "increased vascular action" has been often applied to this condition, although it is evident that the only action an artery is capable of, viz. narrowing of its calibre by contraction of its muscular coat, diminishes the afflux of blood. Determination of blood is a vital process, often very transitory, and frequently occurring as a normal action in those conditions of the system in which, for temporary purposes, an increased afflux of blood is called for by particular organs. The turgor of the erectile tissues, and the afflux of blood to the salivary glands during secretion, afford familiar examples.

An increased local supply of blood lies at the bottom of most surgical processes. No process by which the separation of dead parts is effected, or by which the repair of wounds or ulcers is carried out, can occur without it. Every vascular tissue is susceptible of it; and in active processes in non-vascular tissues it occurs in the nearest vessels. The Surgeon often excites it intentionally as one of the most efficient of his therapeutic means. Under these circumstances, therefore, it can scarcely be considered a disease.

It is, however, frequently associated with disease, forming as it does an essential part of all inflammatory processes.

Causes.—The regulation of the circulation is under the control of the sympathetic vaso-motor nerves. We have before seen that stimulation of the sympathetic causes contraction of the arteries and local anæmia; inhibition or paralysis of the sympathetic causes dilatation. Thus when the sympathetic nerve in the neck of a dog or rabbit is divided, or when in man it is pressed on by a tumour or an aneurism, the arteries in the corresponding side of the head become dilated, a greater afflux of blood takes place, reddening of the skin and mucous surfaces occurs, and the temperature is increased—in other words, determination of blood results. The contraction of the vessels that occurs on stimulation of the sympathetic is always followed rapidly by relaxation with hyperæmia. The vaso-motor nerves may be affected also by reflex stimuli. Irritation of a sensory nerve causes immediate dilatation of the vessels in the area supplied by that nerve. Another marked example of reflex hyperæmia is the engorgement of the kidney that often follows operations upon the urethra, and which may terminate fatally. An irritant applied directly to a part

may cause dilatation of the vessels in two ways, first, in a reflex manner by acting on the sensory nerves of the part; and secondly, by acting injuriously on the arteries themselves, and paralysing their muscular coats. Thus, a blister when first applied causes redness by acting on the sensory nerves; but after it has been on some time, its action extends sufficiently deeply to exert a directly injurious influence on the vessels themselves. This latter condition is a part of true inflammation. Hyperæmia always accompanies the exercise of function; occurring in glands during secretion, muscles during exertion, &c. To this class of causes may also be referred the various forms of normal determination such as erection, or the enlargement of the mammary vessels during pregnancy. Lastly, anæmia of one part may be associated with hyperæmia of another, contraction of the arteries in the one causing a sympathetic dilatation of the vessels of the other. Thus exposure of the surface to cold may cause hyperæmia of the lungs, intestines, or kidneys.

Symptoms.—The symptoms of determination of blood are those that we should expect to result from an increased quantity of blood rushing with increased velocity through the affected textures. They are as follows:—Redness of a bright scarlet hue, swelling from turgescence of the vessels, heat appreciable to the Surgeon as well as to the patient, a feeling of fulness and of throbbing, with an increase in the quantity of the secretions of the part.

Effects.—The effects of simple hyperæmia can rarely be studied uncomplicated by other conditions. It may, however, be broadly stated, that so long as the walls of the vessels are healthy, mere increased flow of blood causes no evil consequences in the affected area. In all cases in which it is the result of local irritation, it is complicated by a greater or less degree of true inflammation. When due to division of a nerve, such as the sciatic, in which are contained motor and sensory as well as vaso-motor fibres, it is difficult to determine how much of the effect produced is due to the mere paralysis of the muscular coat of the arteries. In cases of hyperæmia from pressure upon the sympathetic in the neck, there is some fulness of the face but no actual œdema. There is also in many cases profuse sweating of the affected side of the face. It gives rise to no tendency to capillary hæmorrhage, provided the vessels are healthy; but long continued or frequently repeated determination of blood causes permanent dilatation of the capillaries, and some thickening of their walls. In glandular organs active hyperæmia causes an excessive flow of secretion. Occasionally it may cause hypertrophy; thus, the skin may assume a warty appearance from hypertrophy of its papillæ in the hyperæmic area round an ulcer, and sometimes there may be an excessive growth of hair from the same cause.

PASSIVE CONGESTION.

Passive Congestion or Passive Hyperæmia plays an important part in surgery; it gives rise to serious structural changes and acts as a powerful predisposing cause of inflammation. It consists essentially of accumulation of blood in the affected part from interference with its free return to the heart. The blood in the affected area is not only greatly increased in quantity, but it circulates languidly, and, from its prolonged stay in the capillaries, it becomes more completely de-oxidised than natural, and is consequently of a darker colour. The arteries are, at most, of their normal size, perhaps even they may be contracted, while the veins and capillaries are distended. When the cir-

culation in the congested part becomes completely arrested, *stagnation* is said to occur.

Causes.—The force of gravity plays an important part in many cases as a cause of passive congestion, especially in the pelvic viscera, the veins of which are unprovided with valves. Its effects are, however, even more marked in the leg when, as the result of disease, the valves have become incompetent. Under these circumstances the increased pressure leads to dilatation of the veins and capillaries, and consequently retards the flow of blood through them. This condition is termed hypostatic congestion. The most familiar examples are congestion of the legs from long-continued standing, and of the posterior part of the lungs of those who have been long confined to a recumbent position.

Any mechanical obstruction which increases the resistance in the venous or capillary circulation also gives rise to passive congestion. The obstructing cause in the veins may be outside or inside the vessels—the former being such conditions as pressure of tumours, or of fæces on the pelvic veins, partial strangulation, as in hernia, &c.; and the latter, coagulation of blood in the vein with or without inflammation of its coats, as in white leg or phlegmasia dolens. Congestion in the capillaries and smaller veins alone is most commonly the result of altered vital relation between the wall of the vessel and the contained blood; it then forms a part of inflammation, and is most properly described with that process.

Again, resistance remaining unaltered, passive congestion may be caused by a diminution of the normal forces of the circulation which should overcome it. Thus we see congestion of the extremities in exhausting fevers in which the propulsive power of the heart is greatly diminished; and the same condition readily occurs in old people. Paralysed limbs are usually congested and cold, the congestion arising to a great extent from the want of muscular contractions, which help so powerfully to drive the blood into and through the veins.

Lastly, the propulsive power being unaltered, increased resistance may be interposed in the arterial system and so give rise to congestion. Thus in atheroma the vessels of the leg may be so much narrowed that, although admitting sufficient blood to fill the vessels beyond, the force is so much diminished that it is almost completely expended before the blood reaches the veins, and thus partial stagnation occurs. The most extreme congestion is, however, met with when a small terminal artery, *i.e.*, one not anastomosing with other arteries, becomes suddenly obliterated as by embolism. The blood-pressure is reduced to nothing in the area supplied by the plugged artery, while in the surrounding tissues are communicating capillaries, in which the normal pressure exists; consequently the vessels of the affected part become filled with regurgitant blood, while at the same time there is no force to empty them. A similar condition of intense passive congestion is very frequently met with by the Surgeon in undermined portions of skin which have been deprived of their direct arterial supply by destruction of the subcutaneous tissue, as in phlegmonous erysipelas or superficial strumous abscesses. The blue undermined skin thus produced, may hover between life and death for months, delaying healing indefinitely, and at last requiring destruction before a cure can be obtained.

Effects.—These are of much surgical importance. The first change that usually takes place is transudation of the more watery constituents of the

blood into the surrounding tissue. Hence the spaces of areolar tissue are distended by the effused fluid, giving rise to the condition known as *œdema*.

If the turgidity of the vessels be great and their walls at the same time unhealthy, rupture will occur, and hæmorrhage from the surface or into the substance of the part will ensue. Observations made on the frog's foot after ligature of the main vein show, however, that in moderately intense congestion, the red corpuscles pass through the walls of the capillaries into the surrounding tissues, without any apparent rupture, by a process of diapedesis. This may occur with the passage of very few white corpuscles provided the vessels are healthy. The red corpuscles that thus escape from the vessels break up and are absorbed, but some of the altered blood-pigment remains behind and causes the grey pigmentation of mucous membrane or the brown colouring of the skin, which is so characteristic of repeated or long continued congestion.

Induration from the growth of fibroid tissue, chiefly around the distended vessels, is an almost constant consequence of repeated or long continued passive congestion. But although the affected part may be increased in bulk, the normal tissue is atrophied from the pressure of the new growth. Perhaps the best illustration of this process is afforded by the *nutmeg-liver* that is frequently found associated with obstructive disease of the heart. It may be said briefly that the two most marked post-mortem signs of prolonged or repeated congestion are pigmentation and induration.

The most important effect, however, of passive hyperæmia is, perhaps, the lowering of the vitality of the affected part, rendering it prone to inflame or ulcerate from slight causes. In congestion, although the part contains a great excess of blood at any given time, it is not changed with sufficient frequency, and consequently the amount of blood that circulates is really less than natural.

Symptoms.—Passive congestion of an external part may be readily recognised by the changes it induces in the colour, the size, the feel, the temperature, and the functions of the part. The colour ranges from dark red to bluish purple, but if it has been exposed frequently to previous attacks of congestion, it may be darkly pigmented and brown in colour; it is increased in size; if the congestion is recent and acute it is soft from œdema, and pits under the pressure of the finger; if it is old and chronic the tissues are indurated and brawny. The patient is conscious of a heavy, dull, aching sensation in it, scarcely amounting to pain, but yet attended with uneasiness. The temperature is never above, but often below, the natural standard, and the functions are lessened in activity.

The existence of congestion in an internal organ may be ascertained by finding its size increased and its functions modified, with a sensation of weight in it. The symptoms are often, however, very obscure.

Treatment.—No treatment of passive congestion can be successful unless the cause can be removed. The first indication consists in the removal of any source of obstruction to the return of blood from the part, as by loosening a tight bandage, or elevating a part that has been too long dependent. If the congestion be due to the feeble action of the heart, stimulants and digitalis may be of service in relieving it.

The next indication consists in lessening the quantity of blood in the congested part. The mere removal of the obstructing cause may effect this:

but the desired effect is often hastened by the direct removal of blood by scarification, or by the application of leeches. The over-distended vessels may in some cases be relieved by promoting a free secretion from the part, as by the administration of purgatives for portal congestion. In some parts, again, the judicious application of pressure by means of a bandage will prevent or relieve congestion by limiting œdema and by compressing the dilated vessels, and so causing the blood to flow more rapidly through them, provided the pressure be not sufficiently powerful to interfere with the current through the arteries. With this view elastic pressure is applied to support varicose veins in the leg, and to diminish the mechanical hyperæmia of the skin that usually accompanies them.

The third indication in the treatment of congestion consists in constringing the dilated vessels by the direct application of an astringent to them; thus we apply nitrate of silver to congested mucous membranes, and cold douches to many external forms of passive hyperæmia.

STRANGULATION.

Strangulation is the obstruction of the circulation caused by a narrow circle of pressure acting both upon the arteries and veins, as when a tight bandage is applied round a limb. Strangulation may be at once complete, the circulation through both arteries and veins being simultaneously arrested, as in the application of the tourniquet. The circulation below the band is at once arrested, but no visible changes occur in the part, nor would they do so till gangrene and decomposition commenced. In cases in which strangulation is accidental or pathological it is more commonly incomplete at first; the obstruction acts first on the veins, owing to the lower blood-pressure within them, the flow through the arteries continuing. As a consequence of this the phenomena of passive congestion appear in their most intense form; the parts below the constriction become gorged with blood, purple or black in colour, cold and numb. There is great swelling, and often abundant escape of red corpuscles from the vessels, or rupture of the capillaries with extravasation of blood. As the part swells the constriction becomes tighter, the obstruction to the arterial flow increases, and finally circulation is completely arrested and gangrene sets in.

INFLAMMATION.

The study of the inflammatory process is one of the most difficult on which the Surgeon can enter; but the labour required to master its details is well bestowed, inasmuch as an acquaintance with its nature, symptoms, and progress, gives an insight into the greater part of the Science of Surgery. The management of inflammation as it affects different tissues and organs, and as it in return is affected by various concomitant circumstances, comprises a great part of the duties of a Surgeon. The Theory of Inflammation is a purely physiological and pathological study; and, however interesting its investigation may be, yet, as the discussion of this subject belongs rather to the domain of General Pathology than to that of Practical Surgery, it cannot consistently be entered upon here otherwise than in outline. To gain a full acquaintance with the present state of our knowledge regarding the intimate nature, origin, and

progress of the inflammatory process, the student must consult works on general pathology, and the writings of those observers in this country and abroad who have made inflammation the subject of special investigation.*

Up to a comparatively recent period Inflammation was regarded by all pathologists as a process consisting essentially of "a perversion of the natural acts of nutrition of the part," and most regarded it as a condition of increased activity of the processes of nutrition, if not throughout its course, at any rate, at its commencement. In 1858, Lister as the result of his observations, arrived at the conclusion that, from the very earliest stage, inflammation is not an increase but a decrease of the vital activity of the affected tissues. This theory being, however, difficult to reconcile with the "Cellular Pathology" of Virchow, in so far as that system referred to inflammation, met with but little favour till after the re-discovery by Cohnheim in 1867 of the migration of the white corpuscles of the blood from the vessels during inflammation, a process by which the appearance of new cells in an acutely inflamed area was fully accounted for, without the necessity of supposing any increased activity, either nutritive or formative, in the original tissues of the part during the early stages of the process. From this time forwards all observations have tended in the same direction, until at the present day, the definition of inflammation given by Burdon-Sanderson in 1870, would be almost universally accepted. "Inflammation is the succession of changes which occurs in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality."

Our knowledge of inflammation is derived chiefly from observations of the process artificially induced in some transparent tissue in a living animal. The web of the foot and the mesentery of the frog, and the tongue of the toad, have been chiefly made use of. In order to prove the fact that the processes observed in the frog are identical with those that occur, under similar circumstances, in mammals, the wing of the bat was used by Paget, and more lately the mesentery of the rabbit has also been successfully experimented upon. Lastly, Hueter, by observations made on the mucous membrane of the lip, showed that the processes observed in man are identical with those that occur in the lower animals. Microscopic examination of prepared specimens of inflamed human tissues also shows appearances which are readily explained by what is seen to arise during actual observation of the process of inflammation in the frog.

If the web of a frog's foot be spread out and examined with the microscope, the blood is seen to flow in a continuous stream through the small arteries, capillaries and veins. In any vessel which is of sufficient size to allow several corpuscles to pass at the same time, the red corpuscles flow in the centre of the stream, forming a yellow line, while on each side of this is a colourless zone, free

* The following are amongst the most important Works to which the student may refer for further information on the process of inflammation and on the histological changes it gives rise to:—Billroth, "Lectures on Surgical Pathology" (English Translation); Cornil et Ranvier, "Manual of Pathological Histology" (English Translation); Holmes's "System of Surgery," 3rd edition: Article on "Inflammation," by Mr. Simon and Dr. J. S. Burdon-Sanderson; Green, "Manual of Pathology"; "Lectures on the Process of Inflammation," by Dr. J. S. Burdon-Sanderson, *Lancet*, vol. i., 1876, and *British Medical Journal*, vol. i., 1882; Lister on the "Early Stages of Inflammation," *Philosophical Transactions*, part ii., 1858. Those who read German will find in the second edition of Cohnheim's "Vorlesungen über Allgemeine Pathologie," perhaps the fullest and clearest account of the inflammatory process to be met with in any text-book. Lastly, the more advanced student who has thoroughly mastered the modern views of inflammation cannot fail to gain instruction by reading Sir James Paget's "Lectures on Surgical Pathology."

from red corpuscles, known as the inert layer. In the inert layer is seen an occasional white corpuscle, passing somewhat lazily along, with some tendency to adhere to the wall of the vessel. If from any cause the stream be slow enough to allow of the individual red corpuscles being observed, it will be seen that they show no tendency to adhere to each other or to the wall of the vessel; although, as every one knows, when removed from the influence of the living vessels they show a remarkable degree of adhesiveness, sticking not only to each other but to every solid body with which they come in contact. The arteries show constant slight variations in calibre, which are not rhythmical, and are dependent on causes the exact nature of which is uncertain. The flow through the capillaries varies in rapidity with the state of the artery, being more rapid when the vessel is dilated and slower when it is contracted. In observing the foot of the frog, there will also be seen a beautiful system of branched cells containing pigment-granules, by means of which the animal is able to change the tint of his skin. When the pigment is collected into a closely packed mass round the nucleus of the cell, the frog is pale; when it is diffused evenly throughout the whole cell, the animal becomes of a darker tint. These variations of tint occur under the influence of light, the frog becoming pale when exposed to bright light and dark under the opposite condition. Thus, then, in the healthy web, there are three phenomena of easy observation, which indicate the vital activity of the tissues, the want of adhesiveness of the corpuscles, the variations in the calibre of the artery and the movement of the pigment cells. There is yet another sign of health which is not to be observed with equal ease, and that is that the capillaries allow no more serum to exude through their walls than is necessary for the healthy nutrition of the surrounding tissues, and the amount is such that any excess can be readily drained away by the lymphatics.

Supposing now that some irritating substance be applied to the web, the normal phenomena just described will be disturbed proportionately to the potency of the irritant employed, or, in other words, to the degree of injury done to the tissues. The immediate effect of such an injury is, in most cases, a *dilatation of the arteries*, with an *increased flow of blood* to the area injured. This is spoken of as **determination of blood to the part,—active hyperæmia,—active congestion—or fluxion.** Some irritants, such as ammonia or mechanical violence, cause *contraction* of very short duration, which precedes the dilatation, but this is always of brief continuance and of but little importance. The widening of the artery allows a greater quantity of blood to flow into the capillaries which consequently become dilated in their turn, at the same time the flow of blood through them is accelerated; lastly the dilatation extends to the vein. It would seem at first sight, that dilatation of the channels through which the blood is flowing, would lead to a slackening of the current rather than to an increased rapidity of flow; and so it would, if the dilatation occurred equally in arteries, capillaries and veins,—but this is not the case. The small arteries are capable of very great variations in size, sometimes contracting almost to obliteration and at others expanding to many times their ordinary calibre. The capillaries, on the other hand, are capable of proportionally much less dilatation, and such widening as does take place is purely passive and a consequence of the increased pressure caused by the relaxation of the arteries. The artery in a dilated state will admit to the capillaries it supplies many times the quantity of blood it allows to pass when

contracted, but the combined sectional area of the capillaries is increased only by a fractional part. It is evident, therefore, that the rapidity of the flow must be increased

The cause of the arterial dilatation is twofold. It has been shown by experiment that irritation of a sensory nerve causes dilatation of the arteries in the whole area supplied by that nerve. This is a purely reflex phenomenon. Part therefore of the dilatation is due to this cause, and is not accurately limited to the area injured. In the injured area itself, however, the dilatation is due to the direct effect produced upon the vessels of the part by the injury that has caused the disturbance; here the muscular tissue of the small arteries is paralysed. That this is so is further shown by the fact that the degree of the dilatation is fixed and uniform, all those variations before mentioned as occurring in health being absent.

If the irritant applied to the web of the frog's foot be more powerful, it will be difficult to observe either the stage of contraction, supposing it to occur, or the stage of dilatation with increased rapidity of flow, for before the microscope can be brought to bear on the web, the circulation will have undergone a third change. The vessel will be dilated as widely as possible, but *the flow of blood, instead of being increased in rapidity, will be retarded or even arrested.* In order to observe the development of this state of the circulation with greater accuracy the mesentery of the frog must be made use of, and no further irritation than exposure to the air be applied. In a mesentery, properly prepared and protected from needless sources of irritation, the retardation of the blood-stream may be delayed for many hours. Coincident with the first signs of retardation of the blood-stream, a change is observed in the relation of the corpuscles to each other and to the walls of the vessels. They no longer flow freely and separately onwards, but show an adhesiveness not observed before, in consequence of which they tend to stick to each other and to the wall of the vessel through which they are passing. We have before seen that even in health the white corpuscles show some degree of adhesiveness and are to be seen rolling along the wall of the vessel in the inert layer. It is not surprising, therefore, that the first signs of increased adhesiveness are noticed in the white corpuscles, which fall out of the axial stream more and more and adhere to the walls of the vessels while the red continue to pass onwards. Thus, after a short time, a great increase of white corpuscles is observed in the vessels of the inflamed area; and in the small veins, in which the force of the circulation is least, they soon form a uniform layer, almost like an epithelium, adhering to the inner coat of the vessel. They are, as it were, filtered out of the passing blood, the red passing on whilst they remain behind. After a short time, as the vitality of the mesentery fails, the red corpuscles also begin to become arrested in their passage through the vessels, first in veins and capillaries and finally in the arteries. In the small arteries the first sign of retardation is that a few corpuscles stick to the inner coat during diastole of the heart, and are driven on at the next systole: and thus the stream, which in health is uniform in the more minute arteries, becomes pulsating. As the vitality of the part sinks still lower the accumulation of corpuscles increases till the vessels become choked; the red corpuscles forming, in the frog, a yellowish mass in which the individual cells cannot be recognised. All circulation is thus arrested: a condition known as "**stasis.**" Immediately before stasis becomes complete a slight movement forward may

be noticed with each systole of the heart, followed by a return of the corpuscles to their former situation during diastole, an appearance to which the name of **"oscillation"** is given. The time occupied in the development of complete stasis is entirely dependent on the nature of the injury which causes it. It may be induced instantaneously by the application of any strong irritant to the web of a frog's foot; while, in a carefully tended mesentery, its advent may be delayed for a whole day or even longer. It is evident that the condition of stasis involves a complete arrest of nutrition in the surrounding tissues, which must, unless relieved, inevitably end in their death before long. Should this occur, the liquor sanguinis which still remains in small quantity amongst the closely packed corpuscles coagulates, and stasis becomes converted into **thrombosis**; that is to say, plugging of vessels with coagulated blood. On the other hand, should the tissues not be injured beyond recovery, the condition of stasis gradually passes off; at first some oscillatory movement is noticed; then a few of the corpuscles at the margins begin to break away into the blood-stream, and finally they all seem to lose all tendency to stick to each other or to the vessel, and move off, and the circulation gradually resumes its normal character.

The retarded flow and stasis are degrees of the same condition, and it remains now to consider the causes which bring it about. In the healthy state of the circulation, as before stated, the corpuscles show no tendency to adhere to each other or to the walls of the vessels through which they are flowing; on the other hand, both red and white corpuscles show a very considerable degree of adhesiveness when removed from the body. In sticking to each other and to the walls of the vessels, they are therefore behaving in the living body as if they were in contact with dead matter; and the conclusion derived from this is, that in the healthy living tissues there are forces at work, of the nature of which we are ignorant, which counteract the natural adhesiveness of the corpuscles; but that when the vitality of a part is lowered by damage of any kind, this power is diminished or lost, according to the degree of damage the tissues have suffered, and consequently the natural adhesiveness of the corpuscles comes into play, causing increased resistance to the flow through the vessels and a corresponding degree of retardation of the blood-stream. The accumulation of the white corpuscles is explained by the fact that they possess a greater degree of adhesiveness than the red; their form also favours their adhesion to the sides of the vessels. That the change is not in the corpuscles themselves, nor in the liquor sanguinis, is shown by the fact that, if an irritant be applied to a very small area, so that a corpuscle can be watched through it, it will be seen that the adhesiveness shows itself only while the corpuscle is in the affected area; the moment it passes beyond it, it moves freely on as before. That the retardation of the flow is not the cause of the adhesion of the corpuscles is shown by the fact that, if a ligature be placed tightly round the limb of the frog so as to arrest circulation entirely, no adhesion of the corpuscles to each other or to the vessels is observed till the tissues begin to lose their vitality—a condition which, in the frog, will not come on for twenty-four hours. Cohnheim attributes all the phenomena of inflammation in the first place to molecular changes, accompanied by loss of vitality, in the walls of the vessels; and probably in many cases of inflammation in which the source of irritation is carried to the part by the vessels their walls suffer first. No doubt also, if the capillaries could escape in the case of

a local injury, such as the application of mustard to the web of a frog's foot, the vascular phenomena of inflammation could not occur. But it is impossible, even in imagination, to separate the tissues from the capillaries in vascular parts; and whether the source of damage comes from without, or from within, the vessels, if it is of sufficient power to cause inflammation, the surrounding tissues practically must suffer with the vessels. In the experiments on the frog's foot, Lister showed that the movements of the pigment in the branched cells ceased whenever the flow in the vessels was retarded, proving that they suffered equally with the vessels from the effects of the irritant.

Having thus traced the changes that can be readily observed in the circulation of an inflamed part, we must now turn our attention to **the processes observed in the surrounding tissues and in the walls of the vessels themselves.** For this purpose the web of the frog's foot is not well suited, the mesentery of the frog or tongue of the toad being more convenient for observation. Supposing the mesentery to have been exposed and prepared for examination, the first effect observed will be the dilatation of the vessels; but if proper precautions be taken, the vitality of the part will not for two or more hours be sufficiently lowered by simple exposure to the air to cause retardation of the flow. By the application of an irritant, it might be induced instantaneously, but this would needlessly confuse the experiment. As soon as retardation sets in, the accumulation of corpuscles takes place as before described. If a small vein in which the white corpuscles have arranged themselves along its walls be now watched, the following phenomena will be observed. An individual corpuscle being chosen and carefully watched, a small button-like projection will be seen to rise from the outer wall of the vessel, opposite the point to which it is adhering; this gradually increases in size till it becomes a hemispherical prominence corresponding in width to the remainder of the corpuscle within the lumen of the vein. As the external part increases, that inside the vessel is seen to diminish till the greater part comes to lie outside. It then assumes the form of a pear-shaped body attached to the vein by a stalk, which finally gives way, and the corpuscle is free outside the vessel. When the process of migration is completed, the contour of the vessel remains unchanged, no visible rupture of its coats being observable. The migrated corpuscle is irregular in shape, can be seen to shoot out delicate processes in various directions, which are drawn in again, and thus it moves farther and farther away from the vessel in which it formerly lay. From the close resemblance of these changes of form to those observed in the amœba, they have received the name of "amœboid movements." The whole process is known as **migration of the white corpuscles.** Fig. 82, which was drawn from life by V. Horsley, beautifully illustrates the process of migration. It shows the appearances in the mesentery of a frog which had been exposed for seven hours. The circulation was vigorous in the direction indicated by the arrow. At the commencement of observation there was scarcely a leucocyte outside the vessel-wall. One hour and a half after there were about three times the number represented in the drawing, the excess having been omitted for the sake of clearness. The corpuscles, 1, 2, 3, and 4 (Fig. 82) in and on the wall of the vessel, are consecutive forms assumed by one corpuscle which was watched through the wall of the small vein. The outlines of the red corpuscles are indicated for the sake of clearness, but the current was too rapid during life to admit of their being seen as drawn. As long ago as 1841, Dr. C. J. B.

Williams pointed out the fact that the white corpuscles are present in augmented numbers in the vessels of an inflamed part; but it was Dr. Addison, who, in the same year, first described the passage of the white corpuscles out of the vessels. This observation was confirmed by Dr. Augustus Waller in 1846; but its importance was but imperfectly appreciated even by those who had observed it, and it was in fact generally doubted, till Cohnheim in 1867, published an accurate account of the process, and pointed out its importance in the pathology of inflammation.

As a result of this process of migration of the corpuscles, the tissues of an

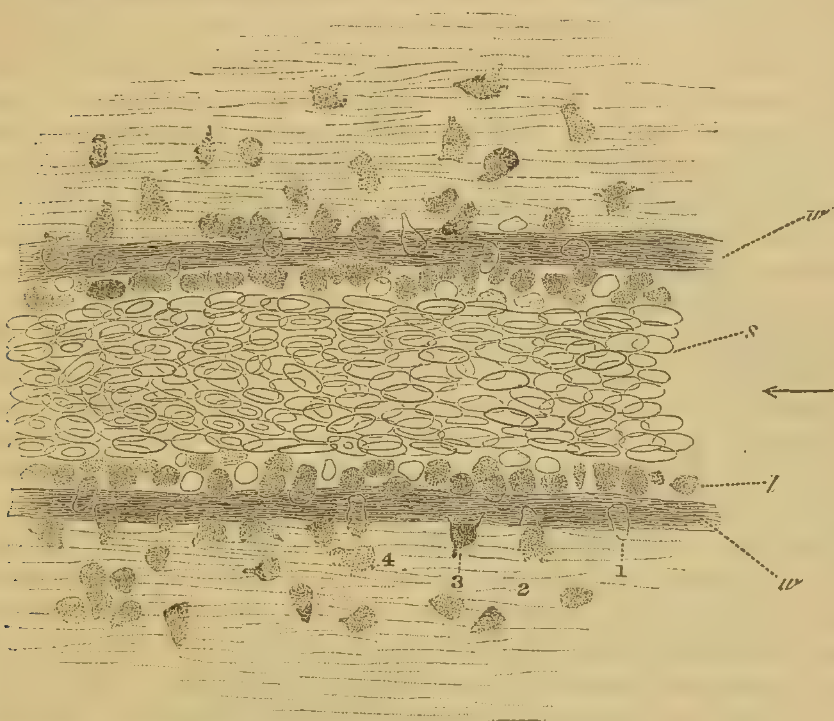


Fig. 82.—Migration of the White Corpuscles, from a small vein. *w*. Wall of vessel. *l*. Leucocyte-layer on inner side of the vessel wall. 1, 2, 3, and 4, Leucocytes in different stages of migration. *s*. Red blood corpuscles (axial stream).

inflamed part soon become crowded with wandering leucocytes, which may accumulate in such numbers as to conceal the normal structures more or less completely. As the inflammatory process becomes more intense, red corpuscles also leave the vessels, finding their way out chiefly from the capillaries, in the same way as has been already described as occurring in mechanical hyperæmia. The number that escapes will depend very much on the degree of obstruction caused by the choking of the capillaries with adherent corpuscles. The migrating cells were at one time supposed to find their way out by natural openings or "stomata," which were believed to exist in the walls of the capillaries between the single layer of endothelial cells, of which these vessels are composed. Although no definite openings are now supposed to exist, yet it is probable that the migrating corpuscles do pass out between the cells, the natural adhesion of which to each other is lessened by changes in the vascular walls, which form an essential part of the inflammatory process. The force that causes the escape of the corpuscle, differs with the red and white. The red are forced out by the intra-vascular pressure only, being

themselves entirely passive. The white probably make their own way out, partly by their amœboid movements, aided by the pressure within the vessel. The part played by the intra-vascular pressure in the migration of the white corpuscles is doubtless very considerable, for the process has been shown to be arrested by a ligature of the main artery leading to the part. This does not however prove that the amœboid movements take no part in the process.

With the migration of the corpuscles occurs another process of equal importance—the escape of an abundant liquid exudation. It has before been stated (see Congestion) that an increase of the intra-vascular pressure, such as is produced by any obstruction to the return of blood through the veins, causes an abundant liquid exudation from the distended vessels. While the vessels themselves are healthy they continue to act as filters to the fluid passing through, and the effused liquid contains little albumen, a large proportion of salts, and is not spontaneously coagulable. In inflammation, the power of filtration is diminished, till in the higher degrees the damaged vessels allow the plasma to pass through almost if not absolutely unchanged. Inflammatory exudation is therefore much richer in albumen than the simple transudation from pressure, and is spontaneously coagulable. Its ready coagulability is due not only to its containing a larger proportion of fibrinogen, but to the presence in it of the white corpuscles which contain the other elements necessary for coagulation—the "fibrin-ferment" and the fibrinoplastin. As this exudation takes place into tissues, the vitality of which is lowered by the damage done to them by the cause of the inflammation, to such a degree that they are behaving for the time being as dead matter, all the essentials for coagulation are present, and the inflammatory effusion tends to coagulate in the affected area. In the process of coagulation a certain number of the migrated white corpuscles break up, yielding their ferment and fibrinoplastin to form the coagulum; but the vast majority remain unchanged entangled in the meshes of the fibrin. The coagulated exudation contracts, just as the ordinary blood-clot does out of the body, and the serum finds its way by the lymphatics back into the circulation. The remaining clot, entangling in its meshes the innumerable wandering leucocytes, forms the so-called **inflammatory lymph**, which distends the spaces of the tissue in which the exudation has taken place. The formation of this inflammatory lymph is limited to the area of inflammation, for any of the effused liquor sanguinis which soaks beyond the area into the surrounding healthy tissues, will no longer tend to coagulate, but will drain off by the lymphatics and return to the circulation. The same will happen with any migrating corpuscles which wander beyond the area of inflammation. If the exudation is very abundant, the lymph-spaces for some distance round the centre of inflammation will be distended with fluid, and thus is produced the œdema which accompanies all acute inflammatory processes. The amount of exudation from an inflamed part is very considerable. Experiments on animals have shown that the amount of lymph returning through the main lymphatic trunk of the thigh after inflammation has been excited in the paw, is many times greater than the normal amount, about one ounce escaping for every drachm that could be collected before the inflammation had been set up.

The Tissues.—The effect of inflammation on the tissues of the affected part has been the subject of much discussion, and cannot even yet be said to

be finally settled. It was shown by Lister, in 1858, that in the area exposed to the action of an irritant every indication of life is in abeyance during the most acute stage of the resulting inflammation. The muscular coats of the arteries cease to show the irregular contractions seen in health, the pigment-cells in a frog's foot no longer exhibit their peculiar changes, and the blood flowing through the part behaves as if in contact with dead matter. He thus sums up the conclusions to which his observations led him. "It appears that the various physical and chemical agents which, when operating powerfully, extinguish the life of the constituents of the animal body, produce

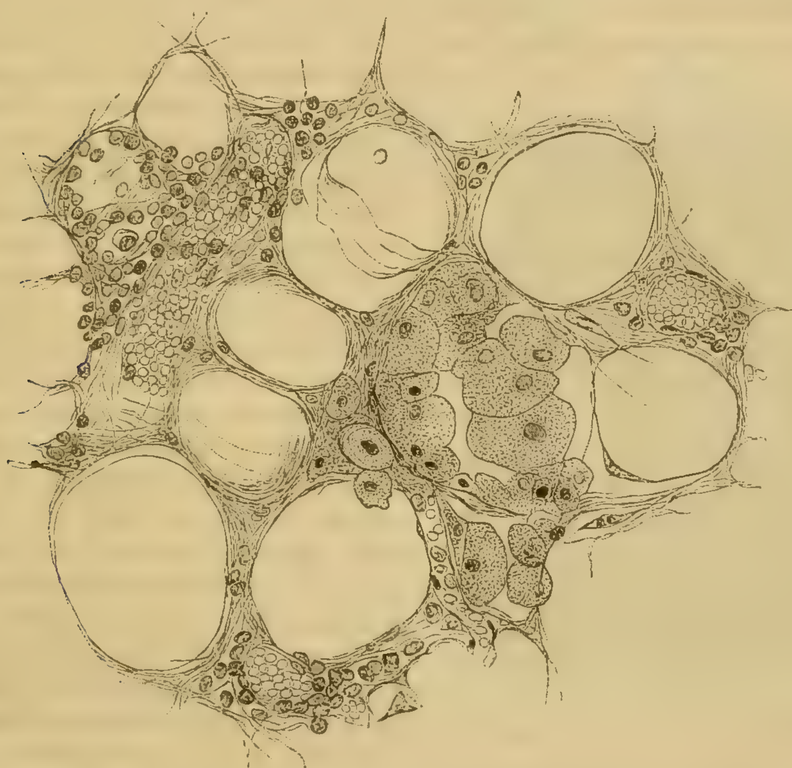


Fig. 83.—Inflamed Fat. Showing the fat cells with leucocytes between them. The migration is most abundant near a small vessel. Some larger cells of doubtful origin are present at one part.

by a somewhat gentler action a condition bordering upon loss of vitality, but quite distinct from it, in which the tissues are, for the time being, incapacitated for discharging their wonted offices, though retaining the faculty of returning afterwards, by virtue of their own inherent powers, to their former state of activity, provided the irritation have not been too severe or protracted." This theory alone was, however, unable satisfactorily to account for the appearance of a multitude of new cells in tissues still suffering from the effect of an injury, and yet the microscope shows that this forms an essential part of acute inflammation. Consequently Lister's theory did not meet with the acceptance it deserved; and until the migration of the white corpuscles was discovered by Cohnheim in 1867, the process of inflammation, according to the Cellular Pathology of Virchow, was regarded as essentially one of increased nutritive and formative activity of the inflamed tissues. All the new cells were supposed to be formed by the rapid proliferation of the

original elements of the affected tissues. The discovery of the migration of the white corpuscles, however, fully accounted for the appearance of the new cells in the inflamed area, without necessitating the improbable assumption, that injury to living tissues immediately increases their vital activity.

The changes which occur in the tissues as the result of inflammation have been observed both in vascular and non-vascular structures, and both during life and in preparations made after death. Amongst non-vascular structures the cornea may be taken as the most typical, and has most frequently been made the subject of experimental investigation. The cornea is composed of a peculiar form of fibrous tissue arranged in strata, between which lie spaces of an irregular stellate form containing corpuscles corresponding with them in shape but not accurately filling them, thus leaving room for the passage of blood plasma and, under certain conditions, of white corpuscles. When the cornea of any animal is irritated by passing a fine silk thread through it, there forms, before many hours are past, an opaque spot extending for a short distance round the part injured. At the same time the vessels of the conjunctiva and of the sclerotic become engorged with blood. If the cornea be cut out and examined about sixteen to twenty-four hours after the injury, in the inflamed area, instead of the single stellate corpuscle naturally seen in each space, there will be found a group of rounded cells having all the appearances of white corpuscles. Till comparatively recently it was thought that these were produced by the division, or, as it is called, proliferation, of the original corneal corpuscles. It has since been shown clearly that the appearance is really produced by an accumulation of migrating cells in the space in which the corneal corpuscle lies, in such a way as more or less completely to obscure the original cell. Whenever and wherever the original cell can be recognised, it shows no change. Senftleben irritated (1) a small central area of the cornea with a solution of chloride of zinc, which kills all cells in the part touched, but leaves the fibrous tissue, and especially the anterior homogeneous lamina, apparently normal; dilatation of the peri-corneal vessels was not produced. The spot remained clear, and the Gold-method showed that the cells around its margin underwent no change until repair commenced; then they shot out processes to form new corneal corpuscles, but nothing suggesting proliferation of the cells was seen. (2) If, however, the anterior lamina was eaten through by the caustic, the area soon clouded; the same occurred if (3) the chloride was applied near the corneal margin, the anterior lamina remaining sound, but then the peri-corneal vessels did dilate. In each of the two latter cases, clumps of small round cells concealed the corneal

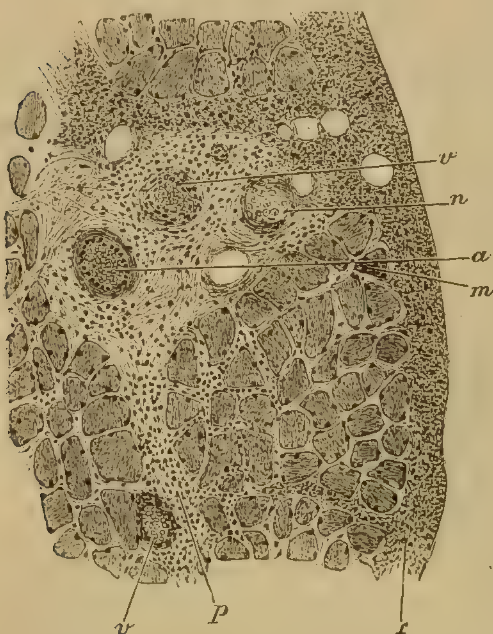


Fig. 84.—*f.* Fascia, œdematous and slightly infiltrated with leucocytes. *a.* Arteriole. *v.* Venule. *p.* Perimysium infiltrated with leucocytes. *n.* Nerve. *m.* Muscular Fibres, cut across.

cells; but there is no reason to suppose that the corneal cells behaved in experiments (2) and (3) otherwise than as they did in experiment (1). We must, therefore, believe that the new cells wandered from the conjunctiva through the anterior lamina in (2); and that they migrated from the dilated peri-corneal vessels in (3).

The tongue of the toad has been examined by Dowdeswell in the Physiological Laboratory of University College with the object of ascertaining whether the fixed connective-tissue-corpuscles take any part in the formation of the new cells which appear in inflammation. The details of his observations were published in the Proceedings of the Royal Society in 1876, and he gives the following brief summary of the results he obtained: "So long as the circulation continued, no change whatever took place in the connective-tissue corpuscles, either as regards form or appearance, notwithstanding that the tissue of which they formed part was beset with innumerable emigrant colourless corpuscles, or (to use ordinary language) was infiltrated with pus." In some cases the tongue was watched for eight or even nine days.

The conclusions drawn from these observations are confirmed by the microscopic examination of specimens of other inflamed tissues. In fat the leucocytes are found crowding between the fat cells, especially in the neighbourhood of small blood-vessels (Fig. 83); in muscle they accumulate between the fibres which themselves show no change, unless the process be very acute, and then the alteration is in the direction of degeneration not of growth (Fig. 84). In bone the Haversian canals become filled with leucocytes; and should the process be of sufficient intensity and duration, the solid tissue disappears before the new cells, while at the same time the bone-corpuscles show no change unless one of degeneration. Thus acute inflammation, from whatever cause, and in whatever tissue it may arise, is always characterised histologically by essentially the same phenomena: a passive or degenerating condition of the original tissues with an abundant infiltration of new cells, which are the white corpuscles which have migrated from the vessels, and possibly, the descendants of such corpuscles formed by division of the parent-cells after leaving the vessel.

The extent to which this process of "cell-infiltration" will be carried depends upon the degree of damage done to the tissues by the irritant which has caused the inflammation. Supposing the damage done to be of a slight and temporary character, the tissues speedily recover from the condition of lowered vitality into which they have been thrown, the vessels recovering with the other parts. The circulation, therefore, returns to its normal state and the exudation of plasma and migration of white corpuscles cease. The liquid exudation drains away, and such leucocytes as have found their way amongst the tissues either break up and are absorbed, or find their way back into the circulation by means of the lymphatics. The part is thus restored to its normal condition, and no permanent effect of the inflammation is left behind. This process of perfect recovery is spoken of as the "termination of inflammation by **Resolution.**"

Should the damage, however, be of such severity that a small portion of the tissue is injured past recovery, or to such a degree that the pressure of the accumulating cells and liquid exudation extinguishes such traces of vitality as may have been left in it, it is evident that the simple process of resolution is

no longer possible. The same will be the case if the cause of the inflammation be persistent, as an irritating foreign body lodged in the tissues. Under these circumstances, the exudation from the vessels and the migration of the white corpuscles continue in the inflamed area, until the leucocytes become heaped up and press upon the original tissues of the part, which now show signs of degeneration. The fibres of connective tissue become swollen and softened, and finally disappear amongst the leucocytes; fat cells lose their contents, and in like manner are lost amongst the invading cells; muscular fibres lose their striation and become granular, the migrating cells penetrate within the sarcolemmata, and the original tissue disappears before them; the vessels in the same way become obliterated by pressure and lost in the mass of new cells. In whatever part or tissue the change may be occurring the process is essentially the same—the original tissues degenerate and disintegrate, and their place becomes occupied by a closely packed crowd of small round cells. Whether each of these cells has originally been a white corpuscle, or whether many of them are formed by division and multiplication of the corpuscles after migration, is a doubtful point. That they are formed from the cells of the perishing tissue is hardly conceivable, and, moreover, experiments have shown that an exactly similar process of cell-infiltration will take place in a piece of dead animal tissue which has been soaked in alcohol, if it be introduced amongst the tissues, or into the peritoneal cavity of a living animal. That these new cells, whatever their source, take an active part in the absorption of the original tissues can hardly be doubted. When the inflammatory process has reached this stage one of two courses is possible: the process may cease and repair may set in—the new cells undergoing changes to be described hereafter, and a scar being formed in the place they occupied—or it may continue and terminate in the formation of pus or **suppuration**. This latter condition is brought about by the softening of the intercellular substance in the centre of the group of new cells. The cells themselves being cut off from proper nutrition by their mutual pressure, undergo degenerative changes. They assume a more circular form, apparently by a process analogous to rigor mortis. Their protoplasm becomes filled with large highly refracting granules, some of which are fatty and soluble in ether, while others are of an albuminoid nature, and can be cleared up by the action of acetic acid. When thus cleared the cell, which now receives the name of **a pus-cell**, is found to contain a double or triple nucleus. This breaking up of the nucleus is not to be looked upon as a sign of active growth, but rather as a degenerative change. The fluid which separates the pus-cells is not formed merely by the softening of the almost inappreciable amount of intercellular substance which separated the heaped up leucocytes in the inflamed area, but partly also by exudation from the surrounding inflamed tissues soaking in amongst them. With this fluid come wandering leucocytes; so that in the fluid freshly drawn from an acute collection of pus, not only are the round dead pus-cells found, but with them many still showing the single nucleus, faintly granular protoplasm and amœboid movements of the white blood corpuscle. The nature of pus, and the process by which a small collection spreads and forms an abscess, will be further discussed under Suppuration and Abscess.

If the process that has just been described should occur on a surface so that the pus finds a ready escape as soon as it is formed, we get another result of inflammation, which receives the name of **Ulceration**. The process of

ulceration is, indeed, identical with that of the formation of a localised collection of pus. The original tissues become infiltrated with migrating cells; they then degenerate, their place being taken by the rapidly multiplying leucocytes which in their turn degenerate and break loose from the surface as pus-cells. This will be further considered under Ulceration. In some forms of inflammation, as will be seen hereafter, the process is brought to an end by the death of the affected part. This is spoken of as the "termination of inflammation in **Gangrene.**"

From the above description of the process of inflammation, it will be seen that the essential features are the retarded flow in the vessels, and the exudation of cells and liquor sanguinis. The simple hyperæmia or determination of blood, that occurs as the result of milder degrees of irritation, cannot be looked upon as constituting a part of the true inflammatory process; and, on the other hand, when the stage of stasis is reached, inflammation must soon be brought to an end by the death of the affected part, unless the circulation be restored by the subsidence of the process. Acute inflammation is identical in all cases; it may vary in degree, in extent, and in termination according to the nature of the cause, and the vitality of the tissues on which the cause is acting, but the process is always the same. When, therefore, varieties of inflammation are spoken of, it must be borne in mind that the variations do not depend on differences in the essential nature of the process, in so far as the changes within the vessels and the exudation are concerned, but are the result of variations in the cause, and in the degree to which the vessels and other tissues are damaged by it.

Causes of Inflammation.—The causes of inflammation, like those of all other morbid processes, may be divided into **predisposing** and **exciting**.

The **Predisposing causes** may be briefly said to include every condition that tends to lower the vitality of the tissues, and thus to render them less able to resist external injurious influences. The conditions necessary for healthy nutrition, and consequently for a high degree of vitality are, an abundant supply of healthy blood, connexion with a healthy nervous centre, periodical rest from functional activity, and at the same time a normal exercise of function. The influences disturbing these conditions may be Local or General.

Local Predisposing Causes.—The local conditions which interfere with the *quantity* of blood supplied to a part, have been already discussed under Local Anæmia and Congestion. In Passive Congestion, it will be remembered that, although the part habitually contains an excess of blood, there is a diminished interchange, and, consequently, the actual quantity supplied is less than natural. Both these local disturbances of circulation, as has been already pointed out, interfere with healthy nutrition, lower the vitality of the affected part, and thus render it prone to inflame from slight causes.

Loss of connexion with a healthy nerve-centre may be the result of destruction of the nerve-centre itself, or of injury to the nerves leading from the centre to the affected part. The best illustration of the effect of this condition is seen in contrasting paralysis of a limb from cerebral hæmorrhage, and paralysis from acute spinal myelitis. In the former case, the paralysed limb is still in connexion with the healthy spinal cord, and ordinary care in avoiding pressure will prevent any formation of bed-sores. In the latter case, the slightest pressure or irritation causes inflammation rapidly terminating in

sloughing. Loss of connexion with a healthy nerve-centre is also seen not unfrequently in cases of division of the ulnar nerve, by which the little finger is absolutely cut off from its nervous supply. Under these circumstances, grave changes in nutrition are common, and inflammation is readily set up. That organs to which *insufficient rest* is given are prone readily to inflame, is, perhaps, best illustrated by the effects of excessive work on the eye; and the converse, that *organs cut off from the performance of their natural function* suffer in nutrition, is seen in the fact that limbs condemned to inaction from disease of a joint are cold and waste away, and that inflammation is set up in them from comparatively slight causes. Wounds in such limbs often heal badly, and it is this that makes amputation of such members notoriously unsuccessful.

Though every tissue of the body is susceptible to inflammation, yet *some parts from their anatomical conditions and structure are more liable* to it than others. All cavities are exposed when wounded to the dangers of the accumulation of putrid or irritating fluids, and thus the serous and synovial membranes readily become affected with extensive spreading inflammation. Mucous and cutaneous surfaces, on the other hand, are protected by a strong and thick epithelium when they are exposed to injury, and consequently require more powerful causes to produce inflammation.

When a part, *having once been the seat of inflammation*, has been left in a weakened or impaired state, it will be more liable to the occurrence of a second attack of inflammation, having less resisting power; hence, also, subsequent attacks are induced by less active exciting causes than were required at first to call the process into existence; we see this in the inflammatory affections of the eyes and joints.

Constitutional Predisposing Causes.—That *old age* acts as a predisposing cause of inflammation, it is hardly necessary to say, the vitality of the tissues in extreme age being greatly diminished. *Anything that enfeebles the heart's action* to such a degree as to interfere with the supply of blood to the tissues, acts as a predisposing cause of inflammation. Thus operation-wounds are more prone to inflame after great loss of blood, and in patients weakened by long fever or want of food. For healthy nutrition, it is not only necessary that there should be an abundant supply of blood, but *the blood that is supplied must be in a healthy condition*. The blood may be rendered impure by *the addition to it of some substance not normally present*, or by the *imperfect elimination of the products of normal tissue-change*, or by the *deficiency of some of its normal constituents*. The most common and most important of the first class of conditions, is the habitual presence in the blood of an amount of *alcohol* in excess of that which can be easily eliminated or consumed. This is unfortunately the constant condition of but too many of the working classes, especially in large cities. A healthy country labourer, engaged in hard work in pure air, may consume and eliminate rapidly a large amount of alcohol; but the city workman, engaged in more or less sedentary occupation in ill-ventilated workshops, is less able to get rid of the alcohol he consumes; while at the same time, the quantity he takes is probably greater, as his wages are higher and his opportunities for drinking more abundant. There can be no doubt that this condition of chronic alcoholism exerts a most prejudicial influence on all operations and diseases of the inhabitants of large cities. *Habitual excess in eating* is almost as injurious as excessive

drinking; for, as only a certain amount of food can be properly digested and assimilated, excess above this tends to interfere with healthy nutrition.

Chronic lead-, mercury-, and phosphorus-poisoning are other examples of the same class of causes. *The absorption of the chemical products of putrefaction from a wound,* as we shall see hereafter, causes severe fever; and the rapid wasting of the body that occurs in this condition, is clear evidence of the serious disturbance of nutrition that it gives rise to. It is the experience of all Surgeons that wounds made during septic fever are exceptionally prone to inflame, and generally do badly.

Saccharine diabetes, which of all conditions exerts the most injurious influence on wounds and injuries, may perhaps be most conveniently classed under this heading; as also may *jaundice* when due to simple obstruction of the bile ducts.

Amongst the causes of *impurity of blood from insufficient elimination* of the normal products of tissue change, Bright's disease of the kidneys is the most important. *Gout* also is perhaps most properly included under this heading. Both these conditions are powerful predisposing causes of inflammation. Diseases of the lungs and liver act in the same way.

Amongst conditions due to the *insufficiency of some of the normal constituents of the blood* is anæmia, such as is so commonly seen in young women; and here also might be classed those conditions due to a deficient supply of the necessary elements of food, such as scurvy, from want of fresh, green vegetables, and the general condition of mal-nutrition brought about by deficiency of oxygen in the air habitually breathed and want of food in general.

Lastly, there is the constitutional condition known as *scrofula,* in which there is a tendency to inflammations occurring under the influence of exciting causes, less in degree than those which affect healthy subjects; but the essential nature of this condition is still but imperfectly known.

Exciting Causes of Inflammation.—Inflammation is usually said to be the immediate result of *local* "*irritation,*" and the causes of inflammation are commonly spoken of as "*irritants.*" Irritation properly means excitement (*irrīto,* I excite); and consequently the physiologists speak of tissues possessing "irritability," when a healthy manifestation of functional activity can be induced by the application of external stimuli. At the time when inflammation was believed to be an exaggeration of the normal activity of the inflamed tissues, the cause that produced it was very naturally spoken of as an irritant. Now that inflammation is known to be essentially a condition of diminished vital activity of the tissues in the inflamed area, the term may give rise to some misconception unless the sense in which it is used be clearly understood; at the same time, its use in the sense of something causing inflammation has become so firmly fixed, not only in surgical but in popular language, that it would be most inconvenient to try to change it. An irritant may, therefore, be defined as something tending to damage the tissues on which it acts, and to lower temporarily their vitality; if acting more feebly, it frequently behaves as a stimulus, calling forth manifestations of normal function; if more severely or persistently, it causes the death of the tissue upon which it acts. Heat may be given as an example. If the skin be exposed to a temperature of about 100° F., there results simple hyperæmia with increase of normal function, as shown by perspiration; boiling water applied merely for a second causes inflammation; and a red-hot iron would, of course, give rise to immediate death

of the part it touched. The *effect produced* by an irritant will depend first, upon the *intensity* of the irritant; and secondly, upon *the powers of resistance of the tissues* on which it acts: thus, in the feeble tissues of a limb, the arteries of which are diseased so as to bring the supply of blood below the normal standard, inflammation is readily induced by slight causes. It has already been stated, that insufficient supply of blood acts as a powerful predisposing cause of inflammation; the complete arrest of the circulation if continued for a sufficient length of time, acts as a direct exciting cause. This was shown by Cohnheim in his well-known experiments on the tongue of the frog and on the ear of the rabbit. If the ear of the rabbit be emptied of blood, and a temporary ligature applied at its base, the effect produced is proportional to the time during which the ear is kept bloodless; if this be a few hours only, temporary hyperæmia alone results, with perhaps slight swelling; if about twelve hours, the ear becomes greatly swollen, there is retarded flow in the vessels with abundant inflammatory exudation, and the tissues become infiltrated with migrating white blood-corpuscles; if the ear be kept bloodless till its vitality is lost, the blood refuses to enter it, the corpuscles immediately choking the vessels and blocking them as in inflammatory stasis, so that any flow is impossible. Thus any degree of inflammation can be produced at will by varying the time during which the ear is kept bloodless. Cohnheim showed also that after the ear has been bloodless for a time sufficient in some degree to lower its vitality, slight injuries cause a higher degree of inflammation than in a healthy ear. This experiment is sometimes unintentionally performed on the human subject. Some years ago a patient came under my care, whose whole arm had been rendered bloodless by the application of an apparatus for the treatment of fracture of the clavicle. At first, when the bandages were removed, the limb seemed hopelessly dead; but after a short time it was evident that, although its vitality was reduced to the lowest possible degree, it was not absolutely destroyed, for the blood began slowly to find its way even to the finger-tips, but with this all the phenomena of acute inflammation were developed. The limb became swollen, red and tense to such an extent that the circulation became again arrested by the pressure of the exudation, and gangrene set in, necessitating amputation at the shoulder-joint. On making incisions into the amputated limb, a most abundant inflammatory exudation, like thin pus, streamed from the subcutaneous tissues and muscles. The same phenomena are observed in strangulated hernia. It is a well-known fact that in complete strangulation, even when the gut has been cut off from the circulation for many hours, no inflammatory exudation is found on its surface when the sac is opened in the operation; but should the patient die shortly after reduction, the gut is found to be covered with a thick layer of inflammatory exudation. Here, as in the rabbit's ear, the phenomena of inflammation do not manifest themselves till the circulation is re-established in the strangulated part.

Irritants, that is to say, injurious influences acting as causes of inflammation, may be divided into six groups: **Mechanical, Physical, Chemical, Organised, Functional**, and **Nervous.**

1. **Mechanical Irritants** may be thus subdivided:—(*a*) *Direct mechanical violence*, as in wounds, bruises, fractures of bones, &c. (*b*) *Movement*, which is a frequent cause of persistence of inflammation, as in inflamed joints, but is seldom an exciting cause of the original mischief. (*c*) *Friction*, as in

blisters on the feet or hands. (*d*) *Tension.* Abnormal tension acts both as a primary and a secondary cause of inflammation; a tight stitch, pent-up discharges in a wound, or obstruction of the duct of a gland, are all familiar examples of tension acting primarily as a cause of inflammation. As a secondary cause it is still more important, as it comes into play to a greater or less degree in all inflammations as a consequence of the dilatation of the vessels and the exudation. In an acute abscess, it is the tension produced by the accumulation of fluid that causes the persistence of the inflammation, which subsides more or less completely as soon as the pus is let out. It is partly the diminution of tension by emptying the over-distended vessels that gives relief in elevation of an inflamed part; in fact it will be seen hereafter that the relief of tension is one of the chief objects in the treatment of almost every inflammation.

2. **Physical.**—Under this heading are included *heat, cold* and *electricity.* The effects of the two first are too familiar to require further explanation. Electricity acts as a cause of inflammation only when it gives rise to decomposition of the tissues by electrolysis.

3. **Chemical.**—All strong *acids* and *alkalies* and innumerable salts, such as corrosive sublimate, chloride of zinc, &c., act as irritants when applied to the tissues. Numerous *natural products of the vegetable kingdom,* such as croton oil, mustard, &c., and *some animal products,* such as cantharides and the poison of various venomous reptiles and insects, act as more or less powerful exciting causes of inflammation. The most important, however, of all this class of irritants in surgical practice are the **chemical products of putrefaction.** It is to the irritation caused by these that the inflammation and suppuration which so frequently accompany open wounds are due, in the great majority of cases; and the great improvement that has taken place in surgery during the last fifteen years has been brought about chiefly by the more or less perfect exclusion of this source of irritation. It is necessary, therefore, here briefly to consider the nature and necessary conditions of putrefaction.

Decomposition or putrefaction of animal matter is now universally recognised as a process of fermentation, the essential conditions of which are 1, *the presence of dead animal matter;* 2, *a sufficient supply of oxygen;* 3, *the presence of water;* 4, *the maintenance of a certain temperature,* and 5, *the ferment.* These may be considered more in detail.

1. **The presence of dead animal matter.**—We have already seen that in acute inflammations a coagulable exudation takes place; when this coagulates it entangles in the meshes of the fibrin, a vast number of white corpuscles, which have migrated from the vessels, thus forming the so-called inflammatory lymph or plastic exudation, while the serum either flows away by the lymphatics or accumulates in the spaces natural to the part. In the case of an open wound the plastic exudation accumulates on the surface and forms, as we shall afterwards see, the first bond of union; while the serum drains away, unless, from any imperfection in the treatment, it is allowed to accumulate in the cavity of the wound. In compound fractures and wounds opening the natural cavities of the body, perfect drainage is not always possible. The plastic exudation is composed to so large an extent of living cells that it may be looked upon as living tissue, and consequently incapable of undergoing putrefaction. It is otherwise with the serum, which is highly putrescible. Extravasated blood, either in the spaces of the areolar tissue, as in a bad

bruise, or in the cavity of a wound, or other injury, as in a compound fracture, is readily decomposable, although less so than the serum which is squeezed out of the clot as it contracts. The pus contained in an abscess, or the urine in a distended bladder, are other examples of putrescible animal matter in the living body.

2. **A sufficient supply of oxygen.**—The tissues themselves and the blood circulating in them, contain quite enough oxygen for the process of putrefaction. This is shown by the fact that offensive decomposition frequently takes place in wounds from which, immediately after the injury, the air has been excluded by some external application, such as styptic colloid, collodion, or the like.

3. **The presence of water.**—All living tissues and the fluids of the body contain enough water to putrefy readily, but the proportion is not that most favourable to the process. The more watery an exudation, the more readily will it decompose.

4. **The maintenance of a certain temperature.**—Experience shows that the temperature of the human body is one highly favourable to the process of putrefaction.

5. **The presence of the ferment.**—The four previous conditions of putrefaction have been universally recognised for a long time past, and may be said almost to form part of the common experience of mankind; but the necessity for the action of a ferment as the starting point of the process is amongst the modern discoveries of science. Ferments are of two kinds, organised and non-organised. The *organised ferments* are microscopic vegetable organisms belonging to the class of fungi; the *non-organised* are chemical substances, such as diastase, pepsin, ptyalin, &c., which give rise to definite chemical changes in the special substance upon which they act. The part played by the microscopic fungi in the causation of fermentation is still doubted by some observers, who attribute the process to the action of particles of dead organic matter supposed to be undergoing certain "physico-chemical" changes, by virtue of which they start similar changes in unstable organic compounds with which they may come in contact. The vast majority of observers are, however, now agreed in considering the process of putrefaction to be a fermentation, dependent on the presence of an organised and living ferment. In putrid, animal fluids more than one form of organism is usually met with; but the most important and constant is a short rod-shaped fungus, the length of which does not exceed double its breadth. This is the **bacterium termo**—supposed to be the ferment of ordinary purefaction. The minute round fungi, arranged in groups, pairs, or chains, which may be present, are not essential to the process; unless the rod-shaped bodies or bacteria are present, the ordinary putrid smell is not produced. These bacteria are true "saprophytes" or "carrion-fungi"; they develope only in dead matter, and soon perish amongst living tissues or in the blood-stream of a healthy living animal. Many forms of microscopic fungi are capable of attacking living tissues and growing amongst them like true parasites: and, as under these circumstances they are associated with, and probably cause a more or less marked disturbance in the health of the part they infest, they have received the name of "*pathogenic fungi*." The ordinary bacteria of decomposition are, in this sense, non-pathogenic. The chemical products, however, of the process of putrefactive fermentation are intensely irritating.

excite inflammation in the tissues with which they come in contact, and when absorbed into the system give rise to constitutional disturbance, varying in intensity directly with the dose.

Assuming, therefore, that the presence of bacteria is an essential feature of the process of putrefactive fermentation, two views have been held with regard to their action and mode of origin. Firstly, that they are the direct cause of the process, and that they arise solely from pre-existing organisms of the same kind, or their germs, which have found admission to the putrescible matter from without. This view, which is known as the "germ theory of decomposition," is now almost universally accepted. Secondly, it has been maintained that, although the microscopic organisms are constantly present, they are merely an accompaniment of the process; and that putrefaction occurs either spontaneously or under the influence of a chemical ferment, and that during its occurrence the bacteria may be developed from the dead matter which is decomposing. The discussion of this question involves the whole subject of abiogenesis or spontaneous generation—a subject that has occupied the attention and exercised the ingenuity of scientific men of all ages and countries, from the time of Aristotle onwards, and which is, perhaps, as far from its ultimate solution now as it was when he wrote on the Generation of Animals. The full discussion of this subject would be out of place here, and I must refer the reader to the writings of Pasteur, Lister, Bastian and Tyndall.

So far as our present purpose is concerned, it may be sufficient to state that it has been shown conclusively by Pasteur, Lister, Tyndall, and others, that putrescible fluids, such as urine, milk, or hydrocele serum, may be exposed without undergoing decomposition to air which has been deprived of all its solid particles by filtration, or has been submitted to a sufficiently high temperature, or to the action of some chemical substance capable of destroying the vitality of any living organism. Consequently the gases of the air are not the causes of putrefaction. If a fluid which has thus been kept from putrefaction for weeks, or even months, be, at the end of that time, exposed to the unpurified air for a few seconds no result may follow; if for a few minutes, fungi are sure to make their appearance; but it is by no means certain that the organism that appears will be the bacterium termo and that the fermentation that follows will be ordinary putrefaction. More commonly moulds of various kinds appear, especially if the air be more than usually dry. If the exposure be prolonged, or the air very damp, the probability of the appearance of bacteria will be much greater. The conclusion drawn from this is that the spores of moulds are always floating in the air in considerable numbers, but that bacteria are much less abundant, but still are always present. The same result may be obtained by cultivating the dust of a room on a gelatine cultivating solution or on a boiled potatoe. In a series of cultivations bacteria appear occasionally, while the moulds constantly develope. By exposing fluids or other cultivating media to the air for fixed times, it can be clearly shown that all forms of organisms exist much more abundantly in the air of houses than in that of the open country, and more in great cities than smaller towns. If, instead of exposing the putrescible fluid to air, a drop of unpurified water from any source be added, bacteria make their appearance with absolute certainty, and ordinary putrefaction follows. From this fact it is to be concluded that water is the special habitat of the ordinary bacteria of putrefaction.

Assuming, therefore, that the bacteria are the cause of the process of putrefaction, by what means can they gain access to the putrescible matter in wounds, abscesses or cavities containing animal fluids?

Only two modes of entrance need be considered: 1. *The bacteria might be conceived to enter by the lungs and alimentary canal*, and thus find their way into the circulation and enter the dead matter from within. That this mode of entrance does not occur with the bacteria of decomposition, is evident from the fact that subcutaneous accumulation of putrescible fluid such as pus, or serum, or portions of dead tissue, such as a part of an organ cut off from its blood supply by a simple embolon, do not undergo putrefaction. It has, moreover, been shown by experiment that the bacteria which cause ordinary putrefaction, even if injected into the blood stream, speedily perish. That other forms of organisms can enter by this method must be acknowledged, unless we are prepared to admit that they are spontaneously generated, for in all acute infective inflammations, and in all acute abscesses, microscopic organisms are found at the seat of disease even when there is no external wound.

2. *The bacteria are admitted directly from without.* Of this there can be no doubt. We have already seen that they are constantly present in the air, although not in such vast numbers as was at one time supposed; they are more abundant, however, in the neighbourhood of decomposing matter, as in a ward containing many wounds the discharges of which are in a state of decomposition. They are carried into wounds, abscesses, or other cavities by the surgeon's hands, by instruments, and more especially by water, unless some means are adopted to destroy them. Still it cannot be too clearly borne in mind that even when they are carried into the body, or into a wound, the ordinary bacteria of putrefaction can do no harm unless they come in contact with dead matter. They speedily perish in the blood, and they exert no influence on living tissues. Amongst living tissues we must class the coagulable lymph or plastic exudation that covers the surfaces of a wound; while the serum is dead matter. In a wound or abscess cavity, therefore, which is perfectly drained, they soon perish; and were perfect drainage always possible, we need not fear the presence of bacteria. It is, however, not possible; and consequently, according to the germ-theory of decomposition, it becomes in most cases a matter of great importance to exclude all bacteria from wounds or abscesses, and to destroy any which may have found admission.

The **bacterium termo,** the ferment of ordinary putrefaction, is a short rod-shaped body, the length of which is under twice its width; it exhibits active spontaneous movements, but occasionally a group of bacteria become united together by a jelly-like substance which limits or arrests their motion. Bacteria multiply, as far as is known, solely by division of the individual cells (fission), and never by the development of spores. They are, consequently, easily destroyed by chemical antiseptics, by heat and by drying, as the extraordinary power of resisting these influences is shown only by the spores of fungi, and not by the organisms themselves.

4. **Organised Irritants.**—This class of irritants includes those organisms which have the power of growing like true parasites, in the living tissues of the animal body. Amongst them must be included certain animal parasites, such as the itch insect (acarus scabici), the chigoe (pulex penetrans), the trichina spiralis, &c., which bury themselves in the living tissues and there excite a greater or less degree of inflammation. These are, however, of little

importance compared to the vegetable organisms which are now supposed by the majority of pathologists to be the direct cause of many forms of inflammation, as erysipelas, malignant pustule, and other specific affections. Assuming this theory to be true, it is probable that the inflammation is the result of the formation of irritating chemical products by a process analogous to putrefaction and fermentation; still it is important to make a very clear distinction between the effects of simple putrefaction and the inflammation caused by these more potent organisms. In simple putrefaction the irritating material is formed as the result of changes occurring in the dead matter only, and may be regarded as being developed outside the body; and, when it gives rise to spreading inflammation, this is due merely to the chemical products of the process soaking into the surrounding tissues, just as any soluble irritating salt, such as corrosive sublimate, might do; but the irritant does not increase in quantity amongst the living tissues, and its effects are directly proportioned to the quantity developed locally. There is, in other words, no *infection* of the surrounding tissues. With the organisms of which we are now speaking, however, the case is different; according to the germ-theory of infection, it is supposed that they grow into the surrounding living tissues, and excite inflammation as they spread; they enter the circulation by the lymph stream, or by the blood vessels, and may multiply in the circulating blood, giving rise to changes in its composition incompatible with life, or they may lodge in distant parts, and there grow and set up local inflammation similar to that at the original seat of disease. From their direct power of exciting unhealthy processes, these organisms are spoken of as "pathogenic fungi." They cause a *true infection both locally amongst the tissues adjoining the part first infected, and generally in the whole system.* The poison multiplies in the body of the affected individual, and the effects it produces are not proportional of the quantity of the original dose inoculated. To inflammations arising from this cause the term **"infective"** is applied.

The organisms which are found associated with "infective" inflammations are classed with fungi, being destitute of chlorophyll and absorbing oxygen and excreting carbonic acid. They belong chiefly, but not exclusively, to the orders **Micrococcus and Bacillus.**

Micrococci are round organisms, varying from $\frac{1}{25000}$ to $\frac{1}{10000}$ inch in diameter, and are often recognizable only by the highest powers of the microscope. They occur singly or grouped in pairs, chains, or colonies. When in colonies they are bound together by a homogeneous substance, known as "Zooglœa." There is no reason to believe that they ever lengthen out into rod-shaped organisms, as they can be cultivated again and again in various media, and still retain their original form. Their mode of reproduction is supposed to be by cell-division.

Bacilli are rod-shaped bodies, differing from bacteria in the fact that their length is at least double their breadth, and that they are most often motionless. This division is merely arbitrary, but our knowledge is not yet sufficient to justify any further distinction. One bacillus is, however, of such size that its life-history can be studied without difficulty, namely, the Bacillus anthracis, the organism which is the cause of splenic fever in cattle and of malignant pustule in man. Observation has shown that, under favourable conditions of growth, it multiplies by fission like the bacteria; but under other circumstances small highly refracting dots appear in its substance, which have been proved

to be spores. These spores show a most remarkable power of resisting heat, chemical reagents, and drying. Blood containing them may be kept dry for years without losing its virulence; it may be mixed for weeks with the strongest watery or oily solutions of carbolic acid without its potency being impaired. Bichloride of mercury, however, in a one per cent. solution is speedily fatal to it, as also is permanganate of potash in a 5 per cent. solution. Pasteur has also shown, that when cultivated in a medium unfavourable to its growth, it loses its virulence gradually until it can be inoculated into an animal with the certainty of producing a mild form of the disease, but yet sufficiently severe to protect from further attacks. The study of these organisms has lately received a still further impulse from the discovery of a bacillus in tubercle. The exact relation of the organism to tubercular inflammations is still to be determined; but no doubt exists as to its presence, and that it plays some important part in the process can hardly be doubted. The tubercle-bacillus, like that of splenic fever, can develope spores, and although it is not yet definitely proved, yet this mode of growth may ultimately be found to establish a distinct line of demarcation between the organisms to be classed as bacteria and those to be included under the name of bacilli. The tubercle-bacillus will be more fully described under Tubercle; and that of splenic fever under Malignant Pustule.

The germ-theory, therefore, of infective inflammations is that, under certain conditions, parasitic fungi take up their abode in a part of the body, frequently already damaged, as in a wound or a centre of suppuration, and then, while growing, give rise to a process of fermentation in the fluids of the part, the products of which are intensely irritating locally and poisonous if absorbed into the system. When they enter into the blood and affect the whole system, the organisms are supposed to act partly by lodging in minute vessels and exciting a process of inflammation similar to that in the original seat of disease at the point at which they are arrested, and partly, like true parasites, by absorbing oxygen and other nutriment to the detriment of the tissues of the body.

Although our acquaintance with the relation of microscopic organisms to infective processes has been vastly increased of late years, by the labours of Pasteur, Koch, Toussaint, Klebs, Burdon-Sanderson and many others, yet we are very far from possessing a complete knowledge of the whole subject.

Admitting to the fullest possible extent the influence of pathogenic fungi in the causation of infective processes in wounds and elsewhere, experience teaches us that the hygienic surroundings of the patient exert an influence of the greatest importance in their development.

Putrefaction is, as we all know, a process quite independent of hygienic conditions; a dead body will become putrid in the fresh air of the country just as surely as in a crowded city, and in the same way pent-up discharges will putrefy in a palace as certainly as in the foulest dwelling of the poor. Under the best hygienic conditions, if putrid discharges accumulate in a wound or in the cavity of an opened abscess, local inflammation and suppuration are excited and union of the wound or closing of the abscess-cavity is delayed. The local and constitutional disturbance will, however, be less than when the patient is exposed to bad hygienic conditions; for the tissues being better nourished, will suffer less from the irritation of the septic matter, and the septic poison entering the system will be more readily eliminated

True infective processes in wounds are rare, even when the discharges are decomposing, unless at the same time the patient is exposed to unhealthy surroundings. In private practice erysipelas is uncommon, pyæmia is scarcely ever met with, and hospital gangrene is unknown, even when no special means are adopted to prevent decomposition of the discharges. If, however, a number of patients whose wounds are treated without antiseptics, be crowded together, as in the case of the wounded after a battle, even if it be in a building which has never before been used for such a purpose, infective processes are certain to manifest themselves. How it is that infective processes characterised by the presence of a specific virus capable of transference from one individual to another, make their appearance under unfavourable hygienic conditions is still far from being fully understood. Assuming that the micro-organisms constantly associated with infective inflammations really stand to these processes in the relation of cause and effect, it has yet to be determined whether each form of infective inflammation is due to a specific organism constantly present in the air or in water and ready to attack the patient when the unhealthy surroundings to which he is exposed, or other causes of mal-nutrition, such as prolonged wound-fever, or constitutional disease, have reduced his strength so far as to make it possible for the parasitic fungi to invade his body ; or whether simple, non-pathogenic organisms may, by growing in the discharge of a wound rendered unhealthy by putrefaction, develope a virulence they did not before possess, and so become capable of invading the living tissues. This subject involves the whole question of the "mutability of bacteria," and cannot be discussed here. Suffice it to say that Koch and other observers have shown that, however the organisms may acquire their virulent properties, and whatever may be their origin, when a characteristic organism has been found associated with a distinct form of infective inflammation, it can be transferred from animal to animal by inoculation and even cultivated artificially in proper media outside the body; and that generation after generation it reproduces itself in the same form, and when inoculated produces the same variety of infective process.

Assuming the presence of pathogenic organisms in the surroundings of the patient, how do they gain admission to the system ? The direct inoculation of a wound is undoubtedly, in the vast majority of surgical cases, the mode of infection. As before stated (see page 9), the air of a hospital ward has been shown to contain, in addition to fragments of clothing, epithelium-cells, &c., which are always found in inhabited rooms, pus cells, fragments of dried scabs, and bacteria, increasing in number in the neighbourhood of a foul, discharging wound. It is evident, therefore, that unless wounds be specially protected, infection of one from another may most easily occur, the danger being diminished proportionally to the separation of the patients and the freedom of admission of pure air. The poison can also undoubtedly be carried from one wound to another by dirty instruments, or sponges, or by the surgeon's hands or clothes.

It cannot be denied, however, that it is possible, in the case of pathogenic organisms, for the infection to reach the local seat of inflammation from within. Microscopic organisms are found in all acute abscesses and in many infective inflammations in which there is no open wound; and, unless we assume that they have been spontaneously generated within the body, we must admit that they have found their way in by the lungs or alimentary canal. We have

before seen that this mode of entrance cannot be admitted in the case of the ordinary bacteria of decomposition; it is equally certain that it cannot be denied in the case of the organisms of infective inflammations. Experience, however, teaches us that it is not by any means common in local injuries; for the total absence of organisms from a wound can be assured, with almost absolute certainty, by means calculated only to protect it from the dust of the air.

Lastly, it remains to be discussed, what is the relation of ordinary putrefaction to the development of infective inflammations?

Ordinary putrefaction acts both generally and locally. The invasion of the living tissues by an infective process may be regarded as a struggle between the virus and the tissues, and anything that lowers the vitality of the latter will favour the former. The putrefying discharges irritate the parts with which they come in contact and directly lower their vitality, as is evidenced by the inflammation set up; and they thus favour the invasion of the tissues by the pathogenic bacteria. This would be only in harmony with the well-known fact common to the animal and vegetable kingdoms, that feeble individuals, or feeble parts of an individual, are most readily invaded by parasitic fungi.

The inflammation set up by the septic matter is accompanied by a more or less abundant formation of pus; and so long as suppuration lasts we have in the wound or abscess a medium in which any pathogenic fungi which may find entrance to it will readily develope.

The contrast between a wound healing aseptically by the first intention and one in which septic suppuration is taking place on the third day is so marked as scarcely to require comment. In the former case, tissues in a full state of vitality are separated merely by a thin layer of plastic exudation so largely composed of living cells that it may fairly be regarded as living tissue; in the latter, the tissues for some distance on each side are lowered in their vitality by the irritation of the products of putrefaction, and are separated from each other by a fluid which forms one of the most suitable media for the development of any true infective virus that may find admission to it.

Generally decomposition of the discharges acts in two ways: first, it depresses the patient by the fever caused by the absorption of the products of putrefaction, and thus renders him more liable to suffer from any general infective process; and secondly, it is a well-recognised fact that the emanations from putrid matter exert an injurious influence on the health of those that inhale them—in fact, the removal of putrescible matter, or the prevention of its decomposition, forms one of the most essential features of domestic and hospital hygiene.

No greater mistake could be made, however, than to imagine that with the prevention of putrefaction all necessary hygienic precautions are ended. As before pointed out (page 10), the products of respiration foul the air and exert a depressing influence on those who breathe it to a degree that cannot be over-rated; and there is no doubt that, much as antiseptics have done in the prevention of infective inflammations, no inconsiderable part of improvement in the results of modern surgery must be attributed to the greater attention paid to general hospital hygiene, especially to the improvements in ventilation and the avoidance of over-crowding.

5. **Functional Irritation.**—Every tissue requires a periodic rest from func-

tional activity for healthy nutrition, but it is very seldom that the want of such rest can act as more than a predisposing cause of inflammation. Occasionally, however, inflammations of joints or of the eyes seem to be directly dependent on excessive exercise of function.

6. **Nervous Irritants.**—The part played by the nervous system in the direct causation of inflammation has always been a question involved in considerable obscurity. That inflammation can take place, and readily does so, in a part completely cut off from any connection with the central nervous system, has been proved by numerous experiments ; in fact, such a condition has already been described as a predisposing cause of the process. The clinical phenomena usually given as examples of inflammation arising from injurious influences transmitted to the affected part by means of the nervous system, are the so-called sympathetic inflammations of the eye and of the testicle, and herpes zoster. In the eye, it is a well-known fact that, when one globe is affected by destructive inflammation following a wound, unless the diseased organ is removed early, the other eye is liable also to become inflamed. The latest observations tend to prove that the inflammation in such cases in reality spreads from one eye to the other by direct extension along the optic nerve to the commissure. Gonorrhœal inflammation of the testicle is in like manner now usually regarded as a direct extension of the inflammation by means of the vas deferens. Herpes zoster is an inflammation of the skin arising from no known external cause, and usually limited to the area supplied by a single sensory nerve. In this case we can scarcely doubt that the cause, whatever it may be, acts in some way through the nerve. Although it is difficult to prove that the nerves take, ordinarily, any active part in the causation of inflammation, there is no doubt they exert an important influence on its progress by their controlling influence on the circulation. Irritation of a sensory nerve is known to cause dilatation of the vessels in the whole area supplied by the nerve; and the painful stretching of the nerves in inflammatory tension, by causing such a dilatation, increases the blood pressure in the inflamed part, and consequently augments the exudation and aggravates the tension.

Varieties of Inflammation.—John Hunter divided inflammation first into two kinds, viz., the healthy and the unhealthy. "The healthy," he says, "probably consists only of one kind, not being divisible but into its different stages." "The unhealthy, admits of vast variety," "according to the kind of health in the constitution or part." He also divided inflammation according to its effects into "the adhesive, the suppurative, and the ulcerative." The term "**adhesive inflammation**" has taken for nearly one hundred years so important a place in surgical language, that it will be better here briefly to define it. Adhesive inflammation is the result of an irritant acting temporarily with such a degree of severity as to cause exudation of almost pure blood-plasma and migration of the corpuscles, with coagulation of the fibrin in or on the injured tissues. At the same time, the damage done by the irritant must not be of such severity as to cause the death of any appreciable amount of tissue ; nor must it continue to act after it has produced the degree of impaired vitality in the vessels necessary to cause the exudation. To take an example ; the damage done by the passage of a sharp knife through healthy living tissues is sufficient to develope in the area acted upon the stage of inflammation characterised by retardation of the blood-stream, exudation of a

coagulable fluid and migration of white corpuscles. The exudation coagulates on the injured surface and in the spaces of the injured tissue, the fibrin and the white corpuscles remain forming what is known as "inflammatory lymph," and the serum partly drains away and partly returns by the lymphatics to the circulation. This inflammatory lymph, or plastic exudation as it is better called, is the material of adhesion in adhesive inflammation, and if two surfaces covered by it are brought in contact, they adhere to each other. The knife can of course act only while cutting the tissues; the moment the cut is made the cause ceases, the effect only being left behind. If no new cause of irritation comes into play (such as the friction of the surfaces on each other, or the presence of foreign bodies, or chemical irritants as putrid matter, persistently-acting, powerful antiseptics, &c.) the effect gradually subsides, the injured tissues recover their vitality, exudation ceases, the coagulated inflammatory lymph remaining glueing the surfaces to each other, and adhesive inflammation is said to have taken place. Should some persistent source of irritation, such as those above-mentioned, be brought into play in the wound, the exudation does not cease so long as the cause of irritation is acting; consequently, such "inflammatory lymph" as may have been formed by the coagulation of the exudation, becomes sodden and softened by the continuous flow from the vessels, and infiltrated by innumerable migrating corpuscles till it breaks up and flows away as pus, and "**suppurative inflammation**" is said to have been developed. At the same time that this is taking place, the tissues which form the surfaces of the wound, being unable in consequence of the presence of the irritant to return to their normal state of vitality, become infiltrated by innumerable wandering cells which fill all the spaces and press upon the original tissues, finally absorbing them and occupying their place; thus the surface of the wound becomes converted into a layer of closely packed leucocytes, the superficial cells of which are continually degenerating, becoming loosened, and floating away in the discharge as pus-cells, their place being taken by new cells forming below. If the development of this new tissue is equal to the disintegration and destruction on its surface, pus continues to flow away, but no further destruction of the original tissues takes place; if it exceeds the destruction, vessels develope in the new tissue, and it sprouts up as granulations (see Repair). If, in consequence of a higher degree of irritation, the destruction exceeds the formation, the process gradually extends into the surrounding tissues; a new layer becomes infiltrated by migrating cells, pressed upon and absorbed, and its place occupied by the crowded leucocytes, which in their turn break down and are thrown off, and thus a progressive destruction of tissue takes place. This process is called **ulceration**; or, in the language of Hunter, "**ulcerative inflammation**" is said to be occurring. If the irritation be still more severe, the migrating cells may perish before they have formed a distinct layer; and, instead of the process just described, in which the original tissues are first replaced by the leucocytes which then break down and melt away as pus, the tissues may themselves undergo direct disintegration, and the products of this change will form part of the discharge, which under these circumstances will contain shreds of the broken-down tissues and be less rich in leucocytes, or in other words in pus-cells. Thus in rapid ulceration the discharge may be scarcely puriform, but composed of serous fluid with the *débris* of the perishing tissues. Lastly, if the irritation be still more intense and rapid in its action, or the original

vitality of the affected part so low that it is incapable of resisting even mild injurious influences, the death of the original tissue will take place with such rapidity that the dead mass will be visible to the naked eye, forming a **slough,** and the process is then spoken of as **gangrenous inflammation.** Thus there is no sharp line to be drawn anywhere between simple adhesive and gangrenous inflammation. One form merges into another, and the effect produced is proportional to the degree of irritation, and the power of the tissues to resist the injurious action of the irritant.

Inflammations are also frequently divided, according to their real or supposed causes, as **Traumatic,** when arising from injury, **Strumous, Rheumatic, Gouty, Syphilitic,** &c., and finally, when the cause cannot be discovered, they are often called **idiopathic.**

Perhaps, however, the most important distinction is into **Simple localised inflammations** and **Spreading inflammations.** The simple localised inflammations are due to causes which act usually only on a limited area and in a temporary manner. A spreading inflammation is one in which the cause is of such a nature as to be continuously developed either in contact with, or in the affected tissues, and which, consequently, extends more or less widely beyond the area first affected.

The most perfect example of a simple inflammation is that produced by the action of a sharp knife on the living tissues. Here the cause is nearly instantaneous in action, and ceases as soon as the cut is made. The effect is accurately limited to the area injured; and, unless some new cause be introduced, the resulting inflammation will not extend, and will subside as soon as the tissues by their inherent vital powers have recovered from the injury. It is familiar, however, to everyone that this favourable result is not always obtained. In many wounds, the signs of inflammation, in spite of our efforts to prevent it, extend more or less widely beyond the injured area, and reach their maximum intensity at the third or fourth day—a time long after that at which the tissues should have completely recovered from the temporary damage done them by the mechanical violence of the knife. It is evident that here there is a new cause introduced which acts much more widely than the original injury. The inflammation has assumed a spreading instead of a simple character. The spreading character may be due to one of two classes of causes. Either there may be some noxious material developed in the wound, and in it only, which soaks away into the surrounding tissues, exciting inflammation as far as it extends; or the noxious material which excites the inflammatory process may have started from the wound and be developing amongst the living tissues themselves, and consequently be theoretically capable of almost indefinite extension. The former condition is still a simple inflammation, although extending beyond the area first injured; the latter is a *true infective process.* To make this more clear, it will be better to give examples of these two forms of inflammation, taking as before a wound as the starting point. As a result of the simple traumatic inflammation which follows as the necessary consequence of the injury, a certain amount of exudation takes place. The fibrin, as before described, coagulates on the surface, entangling the corpuscles in its meshes, while the serum flows away. If from any cause the serum becomes retained between the surfaces of the wound, we have a putrescible fluid at some degree of pressure in contact with the raw surfaces, and unless special means are taken to prevent it, decomposition will

take place. As a result of this process, readily diffusible, chemical products are formed, possessing intensely irritating properties; and in consequence of the slight degree of pressure to which the pent-up fluid is exposed, this noxious material finds its way into the surrounding lymph-spaces, and wherever it goes it damages the tissues and sets up the inflammatory process. In this case, however, the irritating material is formed solely in the dead matter in the wound. Experiments have shown that the organisms which accompany and are supposed to cause the process of putrefaction of dead matter are innocuous to living tissues, and consequently the inflammation will extend only as far as the products of putrefaction diffuse themselves and no further. Thus, although the inflammation spreads beyond the area originally injured, the process is as truly a local one as if it were induced by filling the wound with arsenic or some other diffusible caustic. Although the poison increases in quantity, it does so only at the expense of dead matter in the wound which may be considered as really outside the body.

The **true infective inflammations** are due to the accidental introduction of a poison or virus which possesses the power of increasing in quantity in the living tissues. The effect produced is, therefore, quite irrespective of the size of the original wound or starting point of the inflammation. Thus the prick of a needle in sewing up a body after a post-mortem examination, may start an inflammation extending through the whole arm. In an infective process of this kind the virus exists abundantly in the products of the inflammation, that is to say, in the inflammatory exudation, and if by any means these products are transferred from one part of the body to another, they set up a similar unhealthy inflammation wherever they may lodge; and, in like manner, a similar inflammation may be started in another individual by inoculation of the exudation. The local spread of the inflammation is due to the irritating inflammatory products containing the ferment-like poison finding their way into the lymph-spaces of the surrounding tissues. An infective inflammation may be limited to one part of the body, and spread merely by local infection as in spreading gangrene and phlegmonous erysipelas; or the poison may be taken up by the lymphatics, and cause inflammation similar in character to the original process in the nearest lymphatic glands without infecting the system generally, as in soft chancre and some forms of dissecting wound; or it may be carried throughout the body by means of broken-down clots from the veins of the primary seat of disease, giving rise to local inflammation wherever the fragments of clot may lodge, as in some forms of pyæmia; and, lastly, the poison may enter the blood and multiply in it, giving rise to a general infective process as in septic infection, malignant pustule (splenic fever) or syphilis. The term "infective" is, therefore, applied only to those conditions in which the poison multiplies in the living tissues of the body; when the infection merely spreads locally without affecting the whole system, the result is called a **local infective inflammation**; when the poison enters the system and multiplies throughout it, presumably in the blood, the affection is spoken of as a "**general infective process.**" The multiplication of the poison in the body and the effect produced not being proportional to the quantity originally inoculated, long ago suggested the resemblance of the process by which the poison is developed to fermentation; and in a large number of infective inflammations, organised irritants in the form of definite pathogenic fungi, supposed to be capable of acting as ferments, have been lately

shown to be constantly present in the inflamed area. This is the case in cutaneous erysipelas, spreading gangrene, malignant pustule, glanders, &c. On the other hand, no definite organisms have as yet been discovered in many other distinctly infective processes, as syphilis and soft chancres, and it is open, therefore, to suppose that in these cases the poison may be an unorganised ferment. When a definite organism is constantly found associated with a specific form of inflammation, and when it retains its power of inducing a similar inflammatory process if inoculated into a healthy animal, even after being cultivated in artificially prepared solutions for one or two generations, the organism may fairly be presumed to be the direct cause of the inflammatory process, and the exact mode in which it acts, though of great interest scientifically, is of little importance to the practical surgeon, and need not be discussed here. Such an organism is the bacillus anthracis of splenic fever in cattle, and malignant pustule in man; and as this disease serves as a type of such processes, the reader is referred to the chapter on malignant pustule for fuller information.

Inflammation is also divided into **acute** and **chronic**, according to its intensity and duration. The symptoms, terminations and effects that have already been described are those which characterise the more acute and ordinary forms of the process. Chronic inflammation will be described in a subsequent part of this chapter. So-called *catarrhal* inflammation will also be described separately.

Phlegmonous is a term applied to an acute inflammation in which the cardinal symptoms—redness, swelling, heat and pain—are well marked.

Inflammations of organs are also divided into **interstitial** and **parenchymatous.** By the former term is meant that the process is either limited to or most marked in the interstitial fibrous tissue of the organ; by the latter that the special structures, as the epithelium of glands, are the primary seat of the morbid process, such change as there may be in the interstitial tissues being secondary.

Croupous inflammation is a term applied to the process when it is accompanied by a firmly coagulated fibrinous exudation, either on the surface of a membrane or the spaces of its tissue.

The **Local Signs** of inflammation may be referred to five heads: viz., 1. *Alteration in Colour;* 2. *Alteration in Size;* 3. *Modification of Sensation;* 4. *Increase of Temperature;* and 5. *Modification of Function of the Part Affected.* The first four of these, redness, swelling, heat and pain (*Rubor et Tumor cum Calore et Dolore: Celsus*), have been described from time immemorial as the cardinal symptoms of inflammation. Certain of these conditions may occur separately, or two or more may be associated together, without the existence of inflammation; but it is the peculiar grouping together of them all that most distinctly characterises the presence of this pathological condition. The relative intensity of these changes varies greatly, according to the tissue which is the seat of the inflammation; thus, in inflammation of mucous membranes and of the skin, the alteration in colour is most marked; in inflammation of the areolar tissue, the change in size always attracts special attention; and when a fibrous tissue is inflamed, its sensibility becomes greatly increased. It must not be forgotten, however, that one or other of these signs may be absent, especially pain and heat.

1. **Alteration of Colour** is invariably a local sign of inflammation, and

one of the earliest and most striking; parts that are naturally perfectly pale, as the ocular conjunctiva, assuming the most vivid red colour when inflamed. The redness is due to the dilatation of the vessels and the accumulation of red corpuscles, and, in very acute inflammations, partly to the escape of the red corpuscles from the vessels. The redness of acute inflammation varies with the intensity of the process. Where there is merely determination of blood it disappears completely and readily on pressure with the finger, returning again with the greatest possible rapidity the moment the finger is removed. When the circulation is retarded, the redness disappears and returns more slowly, and a few red spots may remain unaltered by pressure. These are either points at which the process has reached the stage of stasis, or at which red-corpuscles have escaped from the distended capillaries into the surrounding tissues. The tint of the redness varies also according to the activity of the circulation through the inflamed area. When the flow through the vessels is free and rapid, the inflamed surface assumes a bright scarlet tint; but where there is a tendency to stagnation, either from the feeble state of the patient's circulation, or from the inflammation having approached the stage of stasis, the colour becomes a dull purple. The change from bright red to dusky purple is well seen in phlegmonous erysipelas, when the circulation through the inflamed skin becomes impeded, and gangrene is threatening. After acute inflammation it is frequently weeks or even months before the vessels regain their normal tone, and until this has taken place, a certain degree of redness will remain.

Redness is not, however, a constant appearance in inflammation. In non-vascular parts it occurs in the nearest vascular tissues, and not in the part actually suffering from inflammation. In inflammation of the iris the dilated vessels are concealed by the pigment and the change of tint is from the natural brownish or bluish colour to a greyish or greenish, in consequence of a yellow tinge given to the aqueous humour, by the serous exudation into it.

The redness of inflammation disappears more or less completely after death. Where there has been escape of the red-corpuscles red spots remain, giving rise to the appearance known as "punctiform redness." In septicæmia, pyæmia, and malignant forms of the acute specific diseases, the red corpuscles break up in the blood before death, staining the serum and the lining membrane of the heart and great vessels. A similar staining always takes place after decomposition has set in. It is perfectly uniform, without spots or branching lines, and must be carefully distinguished from the redness of inflammation. Increased redness developes also in the most dependent parts after death from gravitation of blood before coagulation. Thus a coil of intestine hanging down in the cavity of the pelvis may become redder than the rest of the gut, and may be wrongly thought to be inflamed.

2. **Alteration in Size.**—The swelling of inflamed tissues is due to the increased afflux of blood and to the exudation from the vessels.

The swelling varies greatly in different localities. It is greatest in loose textures, and least in those which are firm and dense. Thus, for instance, in inflammation of the areolar tissue of the scrotum, the swelling is much greater than in inflammation of the testes. Inflammation of the conjunctiva occasions great swelling, that of the sclerotic but little. In dense hard structures, such as bone and ligament, there is, of course, very little swelling.

If inflammation become chronic, the swelling may terminate in permanent hypertrophy, or thickening, as will hereafter be described.

Swelling diminishes in most cases after death, by the emptying of the vessels, but never completely disappears, and is consequently an important post-mortem sign of inflammation.

3. **Modification of Sensibility.**—There is in inflammation always more or less pain, which is due partly to increased sensibility of the nerves, but chiefly to the pressure and stretching exercised on their terminal branches by the dilated blood-vessels, and by the inflammatory exudation.

That the pressure of the dilated blood-vessels really is a cause of the pain in inflammation is shown by the relief derived from the elevation of an inflamed part. In inflammation of the testicle this is especially marked, as the veins leading from that gland are valveless, and in the erect position the weight of a column of blood, two feet or more in length, acts upon the vessels and tends to increase the intra-vascular pressure. We frequently find, therefore, that the patient is absolutely free from pain while lying flat on his back; but the moment he rises into the erect position the characteristic sickening, aching, and throbbing sensations return.

In inflammation of organs of special sense, instead of actual pain there may be some alteration in the special nervous sensibility of the diseased organ. When the eye is inflamed, subjective flashes of light may be seen; when the ear is diseased, there may be noises of various kinds.

In inflammation of the bladder, there is a constant desire to expel urine; and in inflammation of the rectum, there are frequent attempts at defæcation.

Pain is one of the most prominent symptoms of inflammation, and its existence serves an useful purpose by preventing the patient from using or moving the inflamed part. The intensity of the pain depends more upon the structure affected than on the violence of the inflammation, being, as a general rule, greater in proportion as the tissue affected is incapable of yielding to the pressure exercised on it by the dilated vessels and the effused matters. Hence, in general, the intensity of the pain is in the inverse ratio of the swelling of the part. Thus, the pain of inflamed bone or fibrous tissue is excessive; that of areolar tissue trifling. In erysipelas of the scalp, most pain is experienced in the ears; the pain of an inflamed sclerotic is far greater than that of a conjunctiva similarly affected. In some forms of inflammation pain can scarcely be said to exist, though the disease may assume the most destructive form; thus, in certain inflammatory affections of the throat and of the peritoneum, there is little or none.

The character of pain varies according to the seat of inflammation. When mucous membranes suffer, it is often of an itching or burning character, as in conjunctivitis; when the serous membranes of the chest or abdomen are attacked, it is lancinating or stabbing; aching in osteitis; throbbing when pus is about to form; sickening when the testis is affected. Inflammatory pain is always increased by pressure; when it is produced principally by pressure, the part is said to be *tender*. This tenderness is of great service in a diagnostic point of view; it may be elicited by direct pressure upon the part, as by squeezing an inflamed testis, or by pressing two surfaces together, as in an inflamed joint. In inflammatory pain, especially of osseous and fibrous tissues, there is very commonly nocturnal exacerbation.

It is important to bear in mind that inflammatory pain is often not confined

to the part affected, but radiates extensively along the course of nerves, of which the terminal branches are implicated, perhaps, only to a limited extent. Thus, in inflammation of the testis there is pain in the loins and groins. In deep-seated ophthalmitis there may be exquisite pain along the branches of the fifth nerve over the whole side of the head or face, in consequence of the ciliary branches of the nasal, which are distributed to the iris and choroid, becoming compressed or stretched.

4. **The Temperature** of an external part of the body when inflamed rises above its normal standard, but not above that of the blood in the left ventricle. In inflammation of internal organs, the temperature rises only as the general heat of the body is elevated by the inflammatory fever. John Hunter originally pointed out this fact; he found, in a case of hydrocele, that a thermometer inserted into the tunica vaginalis stood at 92° F. before inflammation had been excited in the sac, and at 98·75° F. after it had been set up. The conclusion to be drawn from these facts is, that the increased temperature in inflammation, when it occurs, is due to the flow of a larger quantity of blood through the part and not to a development of heat in the part itself, dependent on increased tissue-change. This view has been confirmed by the most recent observations, carried out with the greatest exactitude by the thermo-electric apparatus. The opposite view has been maintained by J. Simon, O. Weber and others. The facts that a thermo-electric apparatus has been found necessary to measure the variations in heat, and that observers of the greatest eminence have held opposite views, are sufficient to show that, even supposing heat to be developed locally in inflammation, it cannot be in sufficient quantity to have any appreciable effect on the general temperature of the body or on the local processes in the inflamed part. To the patient, however, there appears to be a real rise of temperature—as Travers truly remarks, "The nerves measure the sensation and not the degree of heat." In many cases the sensation of the patient is that of *burning* in the part, although the actual rise in temperature may be but trifling. This is owing to the exalted sensibility of the nerves.

5. **Modification of Function** invariably occurs in inflammation, and furnishes important local symptoms. The *Functional Activity* of an organ is decreased or abolished during acute inflammation. As acute inflammation is always the result of some injurious influence which lowers the vitality of the affected part, it is evident that this must be the case. The condition is exaggerated in some cases by the pain, the disordered circulation, and the pressure from exudation. An inflamed muscle is impaired in its power of contraction, and an inflamed gland either ceases to secrete or yields a secretion altered in composition by the admixture of products of inflammation. The *natural use* of a part is often interfered with; thus the bladder can contain no urine, the eye can bear no light, nor can a joint be moved, when inflamed. The normal processes of *nutrition* are either modified or arrested; hence softening, degeneration, or even death of the affected tissues, are common accompaniments of inflammation.

Constitutional Symptoms.—The severity of the constitutional symptoms will depend on the intensity, the extent, and the nature of the inflammation, on the previous state of the patient's health, and on the vital importance of the part affected. Thus a moderate degree of inflammation in a part of no vital importance, as the skin, and occasioned by an external cause, as an abrasion, gives rise to no appreciable constitutional disturbance; but if the

part affected be of great importance, as the larynx or the kidney, the general symptoms are proportionally severe. The nature of the inflammation and of its cause exerts more influence than any other condition in the constitutional effects. Simple traumatic inflammation gives rise to symptoms of slight severity and short duration; while septic and infective inflammations may prove fatal by the disturbance they cause in the system generally rather than by their local effects. Thus a simple fracture, although followed by considerable inflammatory swelling, causes but slight constitutional disturbance; while a poisoned wound may prove fatal, though the local inflammation may affect only the last phalanx of a finger.

The constitutional disturbance in inflammation always assumes the form of fever.—**Inflammatory or Symptomatic Fever.**—Inflammatory fever is invariably secondary, being a consequence of the local affection. It is thus clearly distinguished from the so-called "essential" fevers, in which the febrile condition occurs either without any local inflammation or precedes the local affection by a distinct interval, as in the acute specific diseases. The one essential symptom of all forms of fever is elevation of the temperature of the body, or pyrexia; without this, fever cannot be said to be present. It is impossible here to discuss the theories as to the **nature of fever**, but the following facts may be given as generally agreed upon and common to all forms of fever.

In fever there is an increased production of heat, not merely a diminished loss. This is proved by the evidence of excessive tissue-change, such as the disappearance of fat, the wasting of the muscles, the increased excretion of urea and carbonic acid. There is also a considerable increase in the loss of water by the lungs, and often also from the skin. It is possible that in some cases, such as the rigor following operations on the genito-urinary organs, the contraction of the cutaneous vessels may act as one of the causes of the elevation of temperature by diminishing the loss of heat from the skin; but this is merely an accidental condition and not an essential feature of fever.

The increased production of heat takes place throughout the body, being probably most active in the muscles and glandular viscera. It is certainly not developed to any appreciable extent in the inflamed area, for, as before stated, the latest observations tend to prove that there is no elevation of temperature beyond that of the blood in the part actually inflamed; and, even supposing that these observations are in error, it is evident, from the difficulty in detecting it, that the heat developed in the area of inflammation must be in extremely small amount, and quite insufficient to account for the elevation of the temperature of the whole body by several degrees. The fever is not caused by the pain usually accompanying inflammation; for experiments have shown that irritation of sensory nerves tends rather to lower the temperature by causing a certain degree of shock.

It has been clearly proved by experiment that fever can be induced by injecting into the blood-stream noxious materials of various kinds. Substances which, when thus injected, cause fever are said to possess "*pyrogenic properties.*" Amongst the substances possessing marked pyrogenic properties is the lymph returning from an inflamed area, charged, as it is, with the products of the destructive changes which are going on in the part. It has been before stated how largely the flow of lymph is increased during acute inflam-

mation, ounces returning from the diseased part where drachms return from the corresponding sound part. It is evident, therefore, that the effect produced on the blood during inflammation may be very considerable, and will vary with the extent of the inflammation and the amount of local destructive tissue-change which is going on. One substance, which must frequently be present in considerable quantities in the lymph returning from an inflamed area, viz., the so-called "fibrin-ferment," possesses very powerful pyrogenic properties. This, it will be remembered, is the third element which is concerned in the coagulation of fibrin. It is of doubtful composition, but is supposed to be yielded up by the white corpuscles which become desintegrated during the process of clotting of the blood. It is found in considerable excess in the serum, which can be squeezed out of a freshly formed coagulum; and as coagulation of an inflammatory exudation is the same process as coagulation of the blood, it may be reasonably concluded that fibrin-ferment exists in considerable amount in the serous fluid that drains away from a surface or an area in which an inflammatory exudation is coagulating, to form the so-called "plastic lymph." Köhler, Edelberg, Birk, and others have investigated the effects of the injection of the free ferment into the circulation of living animals, and have found that in very large doses it causes rapid coagulation of the blood in the right side of the heart and death. In smaller doses it gives rise to a febrile disturbance closely resembling that produced by the injection of putrid substances. The fever varies in intensity with the quantity of the ferment injected; and, if this be sufficiently small, the animal recovers without serious symptoms after an elevation of temperature of short duration. There seems no reason to doubt the accuracy of these observations. Large numbers of white corpuscles are known to become disintegrated in the process of coagulation, either of pure blood or of an inflammatory exudation. The theory of "*ferment-poisoning*" may thus, in part at least, account for the fever that always accompanies simple inflammations and large wounds, even with aseptic discharges, and that occasionally follows extensive extravasations of blood. Only under very exceptional circumstances in the human subject could the dose of the ferment be sufficient to cause the more severe symptoms that have been experimentally produced in animals; but possibly the explanation of some cases of death from cardiac thrombosis, that is to say, ante-mortem coagulation of the blood in the right side of the heart and the pulmonary artery, may be found in the presence of an excess of free fibrin-ferment. The fever produced by the entrance into the circulation of the products of healthy inflammation is the only form to which the term inflammatory should be properly applied; but practically, in a very large proportion of cases, the pure inflammatory fever is complicated by a disturbance resulting from the admixture of the products of putrefaction or of specific infective processes with those of the simple inflammation. In fact the products of decomposition are amongst the most powerful of all pyrogenic substances, and we have already seen that locally they are amongst the most potent causes of inflammation. The products of putrefaction of animal substances are so varied and uncertain in their chemical composition that it is better not to attempt to specify them. This much, however, may be said to be proved, that, in the case of ordinary putrefaction, the chemical products, and not the microscopic organisms which invariably accompany the process, are the real exciters both of the local inflammation and of the febrile dis-

turbance. The organisms of simple putrefaction, as before stated, can live only on dead matter; and, if they happen to enter the circulation, they speedily perish, unlike the true parasitic or pathogenic organisms which accompany many infective processes and grow and flourish in the living tissues or blood. The effect produced by the absorption of the products of putrefaction is, therefore, proportional to the dose; the poison has no power of multiplying in the system, and, if the dose be not too great, it is speedily eliminated without serious consequences. If the dose be excessive, it gives rise to a train of symptoms which will be described in the chapter on septicæmia. The products of putrefaction are absorbed with great readiness from a raw surface or the charred surface left by a burn; but it is said that the ease with which they are taken up is greatly diminished by the application of some chemical caustics, especially chloride of zinc. Healthy granulation-tissue forms an efficient barrier to absorption under ordinary conditions (presumably from its possessing no lymphatics); but at slight degrees of pressure the pyrogenic substance passes readily through it. Thus in a large wound, such as an amputation, if there is perfect drainage and no decomposition, the febrile disturbance is very slight and of brief duration, ceasing by the third day at the latest; if there is decomposition of the discharges the fever is higher, and reaches its maximum by the third day, subsiding gradually as the granulations spring up and form a barrier against further absorption; if with decomposition there is insufficient drainage and the wound be of sufficient size, the patient may receive such a dose of the products of putrefaction as to die poisoned—a condition which will be further described in the chapter on septicæmia. If, after the granulations have sprung up and fever has ceased, an accumulation of putrid matter takes place in the cavity of the wound, and there is such a want of drainage that the fluid is pent up at some degree of pressure, the fever and local inflammation will return; but should the drainage be made perfect, it will again cease. It is the fever due to these two causes—the products of destructive tissue-change and exudation in simple inflammation, and the pyrogenic products of putrefaction in septic inflammations—that is spoken of as surgical or traumatic fever. Some writers are inclined to limit these terms to the former of these conditions as being a fever inseparable from any large wound or injury, even when subcutaneous, and to employ the terms septic fever for the latter; and perhaps there would be some advantage in so doing.

Fever is also a constant accompaniment of acute infective inflammations; that is to say, of those conditions in which a virus is present which multiplies in the living body, either locally, as in true spreading or infective inflammations, or generally, after entering the blood from the original local centre of infection, as in many forms of septicæmia and in pyæmia, malignant pustule, &c. In some of these conditions it has been shown that an essential feature of the disease is the presence of microscopic organisms of a specific character which have the power of growing like true parasites in the living body. This condition has, however, as yet by no means been proved for all febrile infective processes; and even when the organism seems to be distinctly the cause of the local and general affection, the exact way in which it produces fever is uncertain.

Lastly, the nervous system most probably plays an important part in the process of fever. It can scarcely be doubted that it exerts an all-important influence in the regulation of the general heat of the body, and a hypothetical

centre has been supposed to exist in the lower part of the medulla which controls heat-production, and is in intimate relation with the vaso-motor centre. It seems difficult in any other way to account for the extraordinarily high temperatures sometimes met with in injuries of the upper part of the spine, and for the fever that is always met with during reaction from concussion of the brain or shock. Two theories are, therefore, held with regard to those fevers which are due to the admixture of pyrogenic substances with the blood: the first is that the pyrogenic substance acts directly on all the tissues of the body, giving rise to increased tissue-change with development of heat; and the second is that the impure blood circulating through the medulla disturbs the heat-controlling centre, and thus indirectly acts on the tissues. We are yet very far from fully understanding the exact nature of fever; but what we do know is of immense practical value. We know that in the vast majority of cases in which fever forms a serious feature in surgical practice, it is due to the entrance into the circulation of noxious materials generated locally, and that in its prevention and treatment our first object must be to arrest the formation of the pyrogenic material by local means. For example, in an acute abscess a fluid containing the products of destructive tissue-changes is pent up in a cavity at some degree of pressure, and a certain proportion of the pyrogenic material it contains is constantly finding its way into the circulation. Open the abscess and cut off the supply and the fever at once subsides; but if for want of drainage, the cavity fills again and its contents be allowed to decompose, the fever will return, and this time more severely than before, as putrid matter is more powerfully pyrogenic than the products of simple inflammation; open up the cavity and drain it, and again the fever will subside; but possibly, supposing the patient to be exposed to infection in an unhealthy and overcrowded hospital, a virus, capable of multiplying in the surrounding tissues, and perhaps of increasing, like a ferment, in the blood itself, may find its way from without into the abscess cavity and thence infect the whole system. Under such circumstances, the mere local treatment will no longer be able to arrest the febrile disturbance; and, unless the patient have sufficient vitality to resist its effects, a fatal result must follow.

Symptoms of Fever in General.—Although inflammatory fever or pyrexia presents clinically many varieties, certain symptoms are common to all. The first and most important of these is the *elevation of temperature*, as shown by the thermometer. All temperatures above 99·5° F. must be considered as indicating fever. The fever would be considered slight unless the thermometer rose above 100·5° F.; up to about 102·5° F. it would be considered moderate; from 102·5° F. to 105·5° F., it would be spoken of as high fever, and above that point the term *hyperpyrexia* would be applied to it. Few patients recover from any febrile condition in which the thermometer rises above 107° F.

The temperature is usually taken in the axilla, but occasionally the mouth or rectum may be used instead. In taking the temperature in the mouth, the bulb of the thermometer must be put under the tongue and the lips kept firmly closed for three minutes. In the mouth and rectum the temperatures registered are about half a degree higher than those in the axilla. The temperature in all inflammatory fevers shows the morning fall and evening rise, common to nearly all febrile conditions.

Many febrile conditions arising in surgical practice, especially those con-

nected with acute suppuration and some forms of blood-poisoning are ushered in by *chilliness*, *shiverings*, or *a rigor*. A well marked **rigor** commences with a sensation of cold, accompanied by great nervous depression and anxiety, often amounting to fear, on the part of the patient. The feeling of cold is so intense that the patient covers himself with hot clothing and shivers beneath a heap of blankets till his teeth chatter. If during this, the cold, stage of the rigor the temperature be taken in the mouth, it will be found to be greatly above normal, often as high as 105° F. If the temperature had been taken before the rigor commenced it would have been found that the rise in the thermometer begins some time before the sensation of chilliness sets in. During the cold stage the face is pale and the whole surface of the body is more or less blanched. This is due to the contraction of the arteries of the skin, which is the essential feature of the cold stage of a rigor. The bloodless condition of the skin thus induced is the cause of the sensation of cold, and by limiting the loss of heat from the surface it takes some part in producing the rapid elevation of temperature. After a time varying from ten to twenty minutes or even more, the contraction of the cutaneous arteries yields, and a corresponding dilatation follows. The surface of the body becomes reddish, the face flushed, the skin moist, and gradually a profuse perspiration sets in—sufficient, in many cases, to soak the sheets of the bed. During this, the hot stage of the rigor, the patient feels intensely hot, although the thermometer shows that the temperature is rapidly falling, the loss of heat from evaporation of the perspiration being necessarily very great. In half an hour or more the sweating ceases and the whole rigor is over, leaving the patient weak and exhausted.

In all forms of fever there is *increased frequency of the heart's beat*. This is, as a rule, proportional to the elevation of the temperature and to the degree of weakness of the patient. The face is usually flushed, but by no means always so.

Another feature common to all forms of fever is *emaciation and loss of strength*. The increased production of heat must, in the light of modern science, be regarded as work; and, consequently, during febrile disturbance the patient may as truly be expending force as if he were carrying weights or climbing mountains. At the same time, his appetite is lessened and his powers of digestion and assimilation of food reduced. The rapid exhaustion and emaciation of many fevers is not therefore to be wondered at.

Thirst is always one of the most prominent symptoms, and the appetite is diminished or lost. In almost all high febrile conditions there is *dryness of the skin*; for, although in fever there is an increased elimination of water, this takes place chiefly by the lungs. The mucous membrane of the alimentary canal also secretes less than natural, and to this cause are due the *dry tongue*, the accumulations on the teeth and lips, or *sordes*, and the *constipation* so commonly met with in fever.

In all febrile conditions there is a feeling of lassitude or weariness, and a marked disinclination to bodily or mental exertion. In the earlier stages of very acute febrile disturbance, there may be *delirium* of a violent form: in the later stages, when the strength is becoming exhausted, wandering of the mind or muttering delirium is a common symptom. The patient's sleep is disturbed, he is restless at night, and delirium is more common at that time than during the day.

Severe fever of any kind always leaves the patient weak and anæmic, in consequence of an excessive destruction of the red corpuscles. In the most extreme forms of septic fever, this takes place to such an extent that the serum becomes stained during life by the colouring matter of the disintegrating corpuscles.

The *urine* in all febrile conditions is scanty and high coloured. It contains an excess of urea and urates, and often a deficiency of chlorides. Albumen is frequently met with in all forms of fever.

The **blood** in inflammatory fever doubtless undergoes important changes, but their exact nature is still imperfectly understood. In the days when venesection was a regular part of the treatment of every febrile condition, much attention was paid to the blood that was drawn. It was noticed that in many acute inflammatory affections the blood coagulates slowly, and—partly from this cause and partly from the rapid running together of the corpuscles into dense masses, which sink quickly—an upper colourless layer of coagulated fibrin free from red corpuscles is left at the top of the clot when it is allowed to form quietly in a deep vessel. The tough layer of yellowish fibrin thus formed received the name of the "*buffy coat.*" The absence of corpuscles allows the contraction in the colourless part of the clot to be much more complete than elsewhere, and its upper surface consequently is depressed in the centre, being "*cupped*" as it is termed. The "buff and cup" were formerly much used as guides in estimating the intensity of the inflammation; it has, however, been shown that the buff may occur in other conditions of the system, as in plethora, or pregnancy, or after exercise, without the occurrence of inflammation. The cupped shape of the clot is in some degree dependent on the shape of the vessel into which the blood is received, being most marked when it is deep.

The changes that occur in the liquor sanguinis are due chiefly to the admixture therewith of the products of inflammation taken up from the affected part by the lymphatics and blood-vessels; and it is evident therefore that they must vary considerably according to the nature and intensity of the local process. If the inflammation affects some important organ, the function of which is to take part in the preparation of the blood, or to eliminate from it the products of tissue-change, its composition must be materially altered; but it is at present impossible to state with any definiteness or accuracy the exact nature of the changes that take place. In simple inflammations, the fluid draining away from the inflamed area contains, as before stated, an excess of the so-called fibrin-ferment, and it is possibly due to this that the amount of coagulated fibrin which can be obtained from a given quantity of blood is increased in some inflammatory affections. In inflammations accompanied by putrefaction of the discharges, the products of decomposition are added to the fluids entering the circulation by means of the lymph-stream, and with these microscopic organisms often find their way into the blood. The bacteria which accompany ordinary putrefaction soon perish in healthy blood, being apparently incapable of finding nutriment amongst living tissues. In true infective inflammations, the inflammatory products which enter the blood-stream may in some cases bear with them organisms capable of multiplying amongst the living tissue and giving rise to secondary local mischief or fatal general disease.

The *blood-corpuscles*, both red and white, have been already described as collecting in great numbers in the vessels of the inflamed part. Does this

indicate an increase of both or either of these in the general mass of the blood? There is no reason to believe that in simple inflammations there is any material change in the number of red corpuscles; but in infective inflammations, and in those accompanied by the absorption of the products of decomposition, there is undoubtedly a rapid destruction of the red corpuscles, so that as pointed out by Wharton Jones and Simon, they fall below the natural standard. They are said by some observers to manifest increased adhesiveness, and a tendency to aggregation into clusters by cohesion of their flat surfaces when removed from the body during inflammatory fever. As to the white corpuscles, we know that they are present in augmented numbers in the vessels of the inflamed part: whether they are really more numerous in the blood in inflammation is doubted by Paget, Simon, and others.

Fever is said to *terminate* by **Lysis,** when the symptoms gradually subside; and by **Crisis,** when the fall of temperature is sudden. In the latter case, it is often accompanied by a "*critical evacuation*" as a free flow of urine containing a large quantity of lithates, a profuse perspiration, or a watery discharge from the bowels.

Varieties of Surgical Fever.—Inflammatory fever presents an infinite variety of form, the type which it assumes being dependent: firstly, on the nature of the pyrogenic substance, the admixture of which with the blood is the cause of the disturbance; secondly, on the state of the nervous system; and thirdly, on the occurrence of certain local and specific symptoms determined by the seat of the inflammation. These varieties in the type of the fever arrange themselves practically into two classes—1, sthenic; or 2, asthenic. The terms sthenic and asthenic are not used at the present day with reference to varieties of inflammation as they were in former times; but for the designation of the different forms of febrile disturbance, as observed clinically, we have no better names, and it is convenient to continue to employ them. In all forms of fever there are three distinct stages: those of invasion, exacerbation, and decline. In practice, the recognition of the type or form that the constitutional fever of inflammation assumes is of the first consequence. The treatment of the patient, irrespective of the topical means that the special local affection may require, being altogether determined by the particular form that the concomitant constitutional disturbance assumes, it cannot be too sedulously borne in mind that the local signs, "the redness, swelling, heat, and pain," do not in themselves comprise all the morbid phenomena of inflammation; there is always accompanying constitutional disturbance, and it is the character of this constitutional disturbance or fever that will at last determine the kind of treatment to be adopted; and it consequently requires to be closely studied.

1. *Sthenic Inflammatory Fever* occurs in young or middle-aged individuals of healthy constitution. It is the form usually assumed by the fever that results from the absorption of the chemical products of putrefaction from a large wound during the first week after its infliction, and is often seen in acute inflammations of important organs, or during the formation of acute abscesses.

The stage of invasion is slightly marked: there is chilliness or shivering with a feeling of general illness; but these symptoms may be so transient as to escape observation. In the majority of cases it is not until the constitutional disturbance is fully developed that it attracts attention. The skin is now hot, and there is a rise in the temperature of the body of from 2° to 5°

Fahr. The evening temperature is one or two degrees higher than that observed in the morning. There is a feeling of general languor, and the head is often heavy and hot. The pulse is full, bounding or thrilling, and quickened to thirty or forty beats in the minute above its normal rate. The character of the pulse varies with the part affected and with the cause of the fever. In ordinary traumatic fever, when it assumes the sthenic form, in the formation of acute abscesses, and in the early stages of many specific inflammatory fevers, as erysipelas, it is full and bounding; in inflammation of glandular structures, as the testis or mamma, the pulse is compressible though full; in acute inflammation of serous membranes, as in pleurisy, peritonitis, or meningitis, it is small, incompressible and wiry. The secretions are arrested or diminished in quantity, the tongue is coated with a white fur, and the mouth clammy, usually with much thirst; the bowels are confined, and the skin dry. The urine is scanty and high coloured.

If a favourable termination occur, the fever terminates either gradually, by *lysis*, or more suddenly by *crisis*, often accompanied by critical evacuation. The tongue cleans, the pulse lessens in frequency and in strength, the secretions become more free, the thirst diminishes, and strength and appetite return. This favourable termination can occur in most surgical cases only by the removal of the cause of the fever, as by the opening of an acute abscess, the removal of septic matter by drainage, or the growth of healthy granulations preventing its further absorption. Should the cause persist, the fever may terminate in death, either by exhaustion or by the supervention of some visceral complication, as pneumonia; or the sthenic form may gradually merge into the type that is characterised by debility.

2. *Asthenic Inflammatory Fever* occurs principally in those individuals whose constitutions are broken by privation, dissipation, or by any of the general depressing causes of disease, as grief, anxiety, long residence in a vitiated atmosphere, or old age. In constitutions such as these, frequently met with in all classes, but especially amongst the poorer residents in large towns, inflammatory fever almost invariably assumes this type. The cause of the fever, however, in many cases, determines the type quite as much as the constitutional state of the patient. The asthenic form is met with in all cases of true infective blood-poisoning from wounds; that is to say, in those cases in which the poison which enters the system is not merely the chemical products of putrefaction, but a ferment-like substance capable of multiplying in the living body, as in acute septic infection, pyæmia and malignant pustule. In all spreading gangrenous inflammations the fever assumes the same form; and in erysipelas, although, as before stated, there may be sthenic fever for a short time, the signs of exhaustion rapidly set in. As the asthenic form of fever depends so frequently on general infective processes it is frequently accompanied by secondary complications, as pleurisy, pneumonia, visceral abscesses and the like.

When the asthenic form comes on as a sequence of the sthenic, the symptoms of the one gradually merge into those of the other, the weakness increases, the pulse becomes feebler though its frequency is kept up, the tongue becomes brown and dry, and there is tendency to delirium of a muttering kind.

When the fever assumes the asthenic form from the very first, depression is often strongly marked during the period of invasion; and, even when the febrile state is fully established, the symptoms are not very active. There is through-

out an appearance of heaviness and stupor about the patient, and an early tendency to delirium of a low form, especially at night; the pulse is feeble and very frequent; the skin may be hot and dry, or sometimes moist and clammy; the temperature is from 2° to 5° Fahr. above normal, and shows a marked evening rise and morning fall; the tongue is brown and dry, and sordes rapidly accumulate about the lips and teeth; the cheeks are often flushed, and the eyes may be bright and staring. As the third stage comes on, if the patient recover, there may be a critical evacuation, as sweating or diarrhœa; the pulse subsides in frequency and increases in strength, the tongue gradually and slowly cleans from the sides and tip, the temperature falls often below normal for some days, and the patient slowly and imperfectly regains his strength. Owing to the extreme weakness and feebleness of the heart's action that often accompanies this form of fever there is a great tendency to local congestions, especially hypostatic pneumonia, which may interrupt the progress towards recovery. Even after convalescence the powers of the constitution may frequently be broken for months or for life.

If the disease take an unfavourable course, the weakness of the pulse and the dark incrustation of the tongue increase; the temperature falls often below normal; the skin becomes cold and clammy; hiccup, subsultus and dyspnœa supervene; the muttering delirium gives way to insensibility or even to coma, and death occurs from exhaustion, or as the result of visceral complication. It is this condition that is frequently described as the "setting in of typhoid symptoms."

In patients whose nervous systems have been shattered by intemperance, or who have been exhausted by excessive mental work or excitement, the nervous symptoms that accompany the febrile disturbance may form so prominent a feature of the case as almost to justify the description of a third type, as has been sometimes done, under the name of **Irritative Fever.** In these cases, if the fever assume the sthenic form there is high delirium, often of a furious kind, with wildness of the eye, flushed face and heat of head. More often the fever is from the first of the asthenic type, especially in habitual drunkards, in whom it resembles delirium tremens; there are the same tremor, clammy perspiration and foul tongue, and the delirium is not violent but busy and muttering, the patient being restless and constantly trying to get out of bed; he is sleepless, and unless relief be obtained, signs of debility rapidly come and death takes place either from exhaustion or coma.

TREATMENT OF ACUTE INFLAMMATION.

It is not merely interesting but practically useful, to study the inflammatory process pathologically; for when we have to deal with it therapeutically, the knowledge we have obtained of its causes and nature in the dead-house and in the pathological laboratory serves to some extent as a guide to treatment. Still our knowledge is not yet sufficiently perfect for theory only to direct our practice, and we must on no account neglect those modes of treatment which have been shown by experience to be of use.

Before describing in detail the means adopted in surgical practice for the prevention and cure of inflammation, it would be well briefly to point out the indications furnished us by pathology.

1. Inflammation is the result of an injury done to the living tissues, of

sufficient severity to lower the vitality of the affected part, but not actually to kill it. The agents that act in this way, as we have before seen, are spoken of in surgical language as irritants. Our first object, therefore, in the prevention of inflammation, is *to protect the tissues from all sources of irritation and, failing this, to remove the original irritant as quickly as possible, and to prevent the introduction of fresh causes of irritation.*

Under this heading are included :—the removal of foreign bodies; the avoidance of irritating applications; the prevention of tension, by drainage of wounds and position of injured parts; the relief of tension, as by early opening of abscesses, or by incisions in cellulitis, to allow of the escape of inflammatory effusions; and the prevention of decomposition in the discharges of wounds and abscesses, and the exclusion of specific infective poisons, such as that of pyæmia, erysipelas, or the like.

2. All irritants lower the vitality of the tissues upon which they act, and if of sufficient intensity, cause death of the part. The degree of damage done is proportional, firstly, to the intensity of the irritation, and, secondly, to the vitality or, in other words, to the power of resistance of the tissues. In the prevention of inflammation, or in the limitation of the process, our first object must be to do everything in our power, both by general and local means, *to promote the healthy nutrition of the tissues.*

Under this heading come :—attention to diet; avoidance of alcoholic excess; regulation of the action of the bowels, skin, and kidneys; the treatment of constitutional conditions, such as gout, rheumatism, and syphilis. Locally the chief objects in view are—to preserve a normal state of the circulation by removing causes of congestion, or local anæmia, as by the excision of tumours pressing on vessels, the cure of varicose veins, and the relief of the distended capillaries by uniform elastic pressure; by elevation of the part, or the removal of strangulation; to maintain a normal temperature; and to avoid over-work of the part, as in excessive use of the eye or larynx.

When the inflammatory process is established, we cannot too strongly bear in mind that the vitality of the part is lowered, and that our main objects are—to avoid further depression, which might extinguish such life as remains; to encourage the return of vitality by the maintenance of a normal temperature and by the regulation of the disturbed circulation by such means as we have at our command; and to ensure as far as possible both functional and mechanical rest of the inflamed part.

Inflamed parts are less able to withstand the effects of heat and cold, of chemical irritants, or mechanical violence. Thus, the application of cold or of powerful antiseptic solutions (all of which are more or less irritating), or the necessary injury of a surgical operation, may, in an inflamed part, intensify the process, and even cause sloughing.

3. The essential phenomena of inflammation are: firstly, the dilatation of the arteries with increased blood pressure in the area supplied by the dilated vessels; secondly, the exudation through their damaged walls, which, other things being equal, will be proportional to the degree of intra-vascular pressure; thirdly, the migration of the white corpuscles; fourthly, the complete arrest of the circulation by stasis. The vascular dilatation and exudation cause the inflammatory swelling and give rise to tension, which, acting as a fresh source of irritation, aggravates the inflammatory process. One of the primary objects in the treatment of inflammation is *therefore to*

limit the exudation by diminishing the blood-pressure and, failing in that, to relieve the tension it gives rise to. The blood-pressure may be limited, first, by general means acting upon the heart, as aconite, antimony, and general blood letting; and, secondly, by diminishing the quantity of fluid circulating in the body, as by general blood-letting, saline purgatives, or low diet. The local blood-pressure may be diminished by causing dilatation of the vessels of some other parts—as of the intestines by purgatives, in external inflammations, or of the skin by diaphoretics in internal affections; secondly, by causing contraction of the vessels supplying the inflamed area by the direct application of cold, belladonna, or astringents, or by applying a stimulus at a distance, so as to cause a reflex contraction of the vessels of the diseased part, as in counter-irritation by blisters or mustard plasters; thirdly, by causing a uniform dilatation of all the vessels of the inflamed part and its immediate neighbourhood, so as to lessen local resistance, as in the application of heat; and, fourthly, by elevation of the affected part of the body, by which the return of blood from the part is favoured, and, as has been shown by Lister, a certain degree of arterial contraction induced. Direct pressure on the main artery of the limb would also come under this heading. When exudation is taking place, elevation of the limb favours its return by the lymphatics, and so lessens swelling. Should the part become so tensely distended as to threaten gangrene from pressure on the vessels, the exudation may be allowed to escape directly by incisions, punctures or scarifications. The migration of the corpuscles is limited by cold, which arrests their amœboid movements, and by all means which diminish blood-pressure. Heat favours their migration, and also encourages their moving out of the inflamed area into the lymphatics in cases in which resolution is taking place. It is only the return of vitality in the walls of the vessels, however, that can completely arrest the process of migration.

The tendency to inflammatory congestion, that is to say, choking of the distended vessels with scarcely moving blood, can be relieved in some cases by drawing blood directly from the part by scarification or puncture, or the force of the heart's action may be stimulated in order to drive the blood past the obstruction by the administration of alcohol. Stasis can be relieved only by the general means above mentioned for favouring the return of vitality in the inflamed area.

4. Pain, which forms so prominent a symptom in many inflammations, will be relieved locally by those means, already mentioned, which tend to diminish tension; but in addition, local sedatives—as belladonna, opium, or subacetate of lead—are often of much use. If these fail, sedatives must be given internally.

5. Lastly, the treatment of inflammation includes that of the *febrile disturbance* that accompanies it. This, as we have seen, may be due chiefly if not entirely to the admixture with the blood of the exudation returning from the inflamed part by the lymphatics; in such cases the means adopted to limit the exudation, or to drain it away externally, as in a wound, will limit the fever; in other cases the stream of lymph bears with it the chemical products of decomposing matter from the inflamed area, and thus acquires an additional power of causing fever; this can be prevented only by proper antiseptic precautions, or by draining off the exudation externally. In specific infective inflammations the fever may be due to contamination of the blood by the presence of some poison multiplying in it, as in septicæmia (septic

infection), pyæmia, or malignant pustule. At present we are not acquainted with any means of definitely destroying the poison in such cases; we can only support the patient in every way in our power, by food and careful nursing, so as to enable him to withstand its evil influence. In those cases in which the nervous symptoms of fever are predominant, sedatives must be administered internally. Lastly, certain drugs are used empirically, from their known power of reducing the temperature in fever, amongst the most important of these being, alcohol, quinine, salicylate of soda, and aconite. The application of cold generally to the body by baths or wet packing, or locally to the head by an ice-cap, as recommended by Knowsly Thornton, useful as they undoubtedly are in cases of very high fever, are but empirical modes of treatment, as they attack one symptom only, leaving the cause untouched. No Surgeon should have recourse to these unless it is beyond his power to discover, or to remove, the cause of the fever.

The above principles serving more or less as our guides, we can now consider more in detail their practical application in the treatment of acute inflammation.

The Preventive Treatment of inflammation can be employed only in cases of injury. All injuries of any severity—as cuts, bruises, sprains, or fractures—must necessarily be followed by a certain degree of inflammation; but this simple traumatic inflammation has no tendency to spread beyond the area injured, which, in the case of a clean cut wound, is little more than a microscopic layer of tissue, nor does it tend to pass beyond the stage of simple exudation into that of suppuration or ulceration, unless some further cause of irritation come into play after the injury. When we talk, therefore, of the prevention of inflammation, we do not mean the prevention of the simple adhesive inflammation which follows an injury, for that is impossible; but we mean the exclusion of all sources of irritation which could intensify or prolong the process or make it assume a spreading form.

While describing the causes of inflammation, it was pointed out that in all surgical injuries in which the injured part is exposed to the air, the irritants which we have chiefly to guard against are the products of putrefaction and the specific poisons of the various infective inflammations. It was also shown that the cause of putrefaction is not the admission of the atmospheric gases, but of solid particles which float in the air, and are now almost universally acknowledged to be living microscopic organisms, and that the virus of the various infective inflammations is, certainly in some cases and possibly in all, a specific microscopic organism. The means, therefore, that prevent putrefaction by exclusion or destruction of the microscopic organisms, will, in a great proportion of cases, serve also to ward off the infection of specific inflammations; but not with equal certainty, for, as has before been stated, the causes of putrefaction cannot find their way to the putrescible matter by the blood, while the organisms which are associated with specific infective processes may do so, those characteristic of some diseases being capable of living in the blood-stream. In the prevention of inflammation, it is only the direct contamination of wounds, abscesses, &c., from the air that can be guarded against by local means; and the association of putrefaction with the specific infective inflammations is so close that the two subjects cannot be dealt with separately in so far as local treatment is concerned, and here, therefore, we need deal only with the prevention of putrefaction.

The **prevention of putrefaction** may be carried out by the exclusion of any one of the essential conditions for the process (p. 64). The first of these is the presence of dead organic matter. It is our object, therefore, by drainage of wounds and abscesses, either entirely to remove the putrescible matter or to reduce it to so small a quantity that its effects will be insignificant. The next three conditions, the presence of oxygen, water, and a certain degree of temperature, cannot be excluded from any abscess, wound, or cavity of the body; but the discharges flowing from these may be either received in some absorbent material or allowed to dry in the air, and thus their decomposition may be prevented; and it will be seen, in the treatment of wounds, that these methods are sometimes adopted. The last condition of putrefaction is the presence of the organised ferment; and the destruction or exclusion of this forms the essential feature of those modes of treating wounds, abscesses, or ulcers, which aim at the absolute prevention of the inflammation which results from the irritation of the chemical products of putrefaction. The simplest mode of exclusion of the organisms floating in the air is by *filtration*. It has been shown by experiment that the air filtered through cotton-wool is incapable of giving rise to putrefaction; but this mode of preventing decomposition is rarely practicable for surgery. Consequently, our chief reliance has to be placed on *chemical antiseptics*—that is to say, on chemical substances capable of destroying the vitality of minute vegetable fungi. It must not be forgotten, however, that all chemical antiseptics are in themselves irritants; and, consequently, in using them, care must be taken to protect the tissues as far as possible from their direct action, otherwise, although preventing putrefaction, they may act as causes of inflammation. As we shall have frequently to refer to the use of antiseptics in the treatment of abscesses, ulcers, and wounds, it will be most convenient here to mention the chief substances at present employed, with their properties and peculiarities. Antiseptics vary much in their power, in the irritation they give rise to, and in their effects if absorbed; these points will therefore be alluded to.

It may be stated that no antiseptic vapour which can be of any practical use in surgery has as yet been discovered.

Carbolic Acid is, perhaps, the most extensively used of all antiseptics, though by no means the most powerful. In surgery the purest acid only should be used, the form known as absolute phenol being perhaps the least objectionable in its smell. The impure form of the acid, such as is used for disinfecting drains, is more difficult of solution in water, and its smell is very offensive. The pure crystallised acid may be made permanently to assume the form of a dense oily liquid by the addition of about $\frac{1}{20}$ of its bulk of water, but true solution does not take place till the proportion of water is about 19 to 1 of the acid, thus forming the 1 in 20 solution. The efficient strength of the watery solution as an antiseptic is about 1 in 50, below which it must not be reduced. Carbolic acid is readily soluble in oil in any proportion up to equal parts, and in glycerine it is even more soluble. The preparations used in surgery are:—*Watery solutions*, 1 in 20 and 1 in 40. The former is applied only to foul wounds for the purpose of cleaning them, to wounds which have been exposed to the air for some time, and to the unbroken skin round the region in which an operation is to be performed; the latter is used to wash the operator's hands and the sponges, and all instruments during the operation, and to irrigate the wound during the performance or to wash it out with at

the end before closing it. The 1 in 20 solution is used for the spray as will hereafter be described. Both the 1 in 20 and 1 in 40 solutions whiten any raw surface to which they may be applied, but their action is very superficial and does not interfere with primary union of a wound. At the moment of application they cause severe smarting, but this is soon followed by relief from all pain and a sensation of numbness. *Oily solutions* act much less powerfully than the watery. For preserving catgut ligatures a solution of 1 in 5 must be used. In the strength of 1 in 10 it may be applied on lint to a wound as an antiseptic dressing, but it loses its acid rather quickly, especially if there is much discharge, and consequently must be renewed at least twice or three times a day. *Glycerine solutions.* The pharmacopœial solution of 1 in 5—one part of carbolic acid to four of glycerine—is too strong for application to a raw surface, but may be used on the unbroken skin; for wounds the solution may be reduced to 1 in 10 by the addition of an equal quantity of water or glycerine. If used as an antiseptic dressing it must be changed frequently, as it is readily washed out of lint by the discharge. *Carbolic gauze.* This is a coarse gauze impregnated with carbolic acid dissolved in a mixture of paraffin and resin. It contains about $\frac{1}{12}$th part of carbolic acid. It forms an absorbent dressing, and possesses the great advantage of yielding up its carbolic acid slowly, and thus retaining its antiseptic properties for a long time. *Carbolised cotton wool and tow* have also been used, but are somewhat inefficient preparations.

Carbolic acid may act injuriously both locally and generally. If the solution be not properly prepared small globules of the undissolved acid may be floating in it which will cauterise both the patient's tissues and the Surgeon's hands. To avoid this it is better always carefully to measure the acid and to prepare the solutions some hours before they are used. If the solution is prepared immediately before use it must be well stirred; and, if it is not required to be cold, warm water may be used to ensure perfect solution.

Carbolic acid is, even in the strength of 1 to 40, an irritant to the living tissues; when applied to a wound it exaggerates the serous discharge for the first twenty-four hours, and consequently increases the necessity for good drainage. In using it as a dressing the object of the Surgeon must be to prevent direct contact of the acid with the raw surface as far as possible after the wound has been once washed out; otherwise it may give rise to suppuration. In washing out a wound also it is important to take care that the lotion used escapes freely. If it remains in hollows and cavities of the wound its absorption may cause symptoms of poisoning; and if it be forced into the spaces of the areolar tissue, not only may constitutional symptoms appear, but considerable local inflammation may supervene. In some patients the skin is singularly intolerant of the acid, and the gauze may cause even vesication. Its use must then be abandoned, and some other antiseptic agent employed in its place.

Carbolic acid cannot be applied either to the unbroken skin or to a raw surface without a certain quantity being absorbed. As a rule this gives rise to no unpleasant symptoms; but, if the surfaces be very large or the patient be peculiarly intolerant of the acid, symptoms of carbolic poisoning may arise. In every case in which a carbolic acid dressing of any kind is applied, it or its derivatives, can be detected in the urine by proper tests: and in a great proportion, if a surface of any size is covered by the dressing or a large wound is

washed out with the lotion, the urine undergoes a marked change. In the mildest cases it is passed clear, but after standing for some time gradually assumes an olive green tint; in the more severe cases it is passed dark in colour, and on standing becomes almost black. If no other symptoms are present this appearance of the urine, which is said to be due to the presence of indican, need give rise to no anxiety. In cases in which the graver symptoms of poisoning are present, the sulphates disappear completely from the urine. The most marked feature of carbolic acid poisoning from absorption from a wound is severe and incontrollable vomiting; if the dose have been very large collapse speedily sets in, with insensibility of the pupil, twitching of the muscles, a rapid feeble pulse, and a subnormal temperature. Albumen is said to appear in the urine. In other cases elevation of temperature has been noted, with vomiting, followed by insensibility and death. With the exception of a few recorded cases, which must be attributed to an idiosyncrasy on the part of the patient, dangerous symptoms have occurred only when the carbolic lotion has found its way into some cavity as the rectum or peritoneum or pleura, or when large abscess-cavities have been washed out with the lotion, or when it has been forced into the spaces of the areolar tissue, as in attempts to disinfect deep wounds or compound fractures. The treatment consists in removing immediately all carbolic acid dressings and substituting some other antiseptic. The patient must be supported by stimulants, especially hypodermic injections of ether; and friction of the surface should be employed. Ice may be given to allay the vomiting. Bauman has recommended the administration of sulphate of soda in small doses frequently repeated, with the hope of converting the carbolic acid into the non-poisonous sulpho-carbolate. This treatment was suggested by the disappearance of the sulphates from the urine, which is possibly due to their having been consumed in that way; the graver symptoms supervening when they were exhausted and free carbolic acid became present in the blood. The drug can do no harm and should certainly be tried.

Carbolic acid has now been more than twenty years before the profession as an antiseptic, and has derived great importance from being the agent selected by Lister for his antiseptic system of treating wounds. In spite of the efforts of Lister himself and many other Surgeons to find some efficient substitute which shall be free from the inconveniences attending the use of carbolic acid, it still holds its place as the most convenient antiseptic for cleaning the Surgeon's hands and instruments and for washing out the wound. Other agents have, however, been largely employed as dressings, and have been proved to be thoroughly trustworthy.

Chloride of Zinc.—The efficient strength of this antiseptic, which is the active agent in Burnett's Fluid, is doubtful; but it probably acts antiseptically in the strength of about half a grain to the ounce of water, or even less. Its use in the treatment of wounds was introduced by Campbell De Morgan more than twenty years ago. It is usually employed in the strength of 20 or 40 grains to the ounce of water. This solution produces a whitening of the surface, but the action is very superficial, and it does not cause the formation of a visible slough unless applied for some length of time; in fact, even in this strength, it does not prevent union by first intention. The whitened surface has been shown by experiment to form a remarkably efficient barrier to the absorption of the chemical products of putrefaction, and experience

proves that decomposition of the discharges will not commence in a wound thus treated for about three days. It therefore forms a most useful application to wounds in which it is impossible to employ rigid antiseptic treatment, such as those opening into the mouth, rectum, or bladder; for by the third day, when its influence seems to be exhausted, the opened lymph-spaces are so far closed by plastic exudation that the dangers of septic absorption are greatly diminished. It has no toxic effects when thus applied; but care must be taken in using it, if a syringe be employed to squirt the lotion into the wound, that the spaces of the areolar tissue are not injected, or serious and extensive sloughing may result.

Boracic Acid was introduced into surgical practice by Lister. It is one of the less powerful, and at the same time one of the least irritating of chemical antiseptics. It is very readily soluble in hot water, but sparingly so in cold. The concentrated cold solution or "*boracic acid lotion,*" is prepared by adding one ounce of the crystallised acid to a pint of boiling water, and afterwards allowing it to cool and the excess of the crystals to settle down; it forms a useful lotion for washing or irrigating wounds. *Boracic acid lint*, which is prepared by dipping ordinary lint in a concentrated boiling solution of the acid and afterwards drying it, forms a useful application to wounds or granulating sores; and, if moistened with warm boracic acid lotion, may be applied with great advantage in the place of a poultice to sloughy and inflamed wounds. *Boracic acid ointment* forms an excellent dressing for small wounds, such as those on the face and for healthy granulating sores. The most convenient form is a preparation composed of 1 part of paraffin and 2 parts of vaseline as a basis, to five parts of which is added one part of boracic acid. It should be spread on thin muslin and dipped in the boracic acid lotion before being applied, after which it may be covered with cotton-wool and allowed to dry. It requires changing once or twice a day. Barff has recommended a chemical combination of glycerine and boracic acid, to which he has given the name of Boro-glyceride, as a lotion for wounds and sores, and those who have used it report favourably of it; but, probably, equally good results can be obtained by adding some glycerine to the ordinary boracic lotion.

Salicylic Acid is a derivative of carbolic acid, and is largely used as an antiseptic. It possesses no toxic properties, and in this respect presents advantages over carbolic acid. It is sparingly soluble in water, requiring at least 300 parts of cold water to dissolve it, and is in this form a less certain antiseptic, though less irritating, than carbolic acid. The preparations used in surgery are *salicylic wool, salicylic jute*, and *salicylic silk*. The jute is recommended by Thiersch as being more absorbent; the silk is prepared from refuse material, and was introduced by McGill of Leeds; it is very absorbent and elastic. All these preparations contain a proportion of the acid varying from 3 to 10 per cent. They should be moistened with a little glycerine to prevent the dust of the acid from flying about when they are used, as it causes violent sneezing. Salicylic acid in solution should not be used for instruments as it corrodes them quickly.

Sulphurous Acid is but little used as an antiseptic on account of its extremely unpleasant smell. It is very irritating, and presents no advantages over those already mentioned.

Iodine is one of the most powerful of all antiseptics. It has been recommended by Bryant as a lotion for washing wounds and sponges, in the strength

of two drachms of the tincture to a pint of warm water ; and in this strength, it is an efficient antiseptic and very free from irritating properties.

Eucalyptus Oil is a powerful antiseptic, having a very fragrant camphoraceous smell ; and, so far as is at present known, it is quite free from poisonous properties. It is practically insoluble in water, but readily soluble in oil, paraffin, and spirit. It is used chiefly as *eucalyptus gauze.* The material with which the gauze is impregnated is composed of 3 parts Dammar resin, 3 parts paraffin wax, and 1 part eucalyptus oil. Lister has used this preparation extensively, and finds it in every way an efficient substitute for the carbolic gauze in cases in which the patient shows signs of carbolic acid poisoning, or when the skin is easily irritated by that substance. For application to granulating sores an ointment composed of 2 parts paraffin, 2 vaseline, and 1 of eucalyptus oil will be found very useful. If the sore be foul some iodoform may be added in the proportion of one drachm to the ounce.

Iodoform is an antiseptic of undoubted power which has lately been used very largely in surgical practice. It is sold in two forms—the precipitated, which is an extremely fine yellow powder ; and the crystalline, composed of fine golden yellow crystals. The latter should always be used in wounds or on raw surfaces, as the finely divided particles of the precipitated form are too readily absorbed. Iodoform is insoluble in water but is readily soluble in chloroform and ether, sparingly so in alcohol, and very freely in oil. The preparations used in Surgery are the pure drug in crystals ; *iodoform wool,* prepared by impregnating cotton wool, deprived of its grease so as to render it absorbent, with 10 per cent. of the drug ; and *iodoform ointment,* made by mixing varying proportions of the crystals, from one drachm upwards, with one ounce of vaseline. The pure iodoform is specially applicable to wounds opening into cavities, such as those left by removal of the tongue or upper jaw. It may be sprinkled on the raw surface twice a day, and will absolutely prevent any unpleasant smell. The Germans have used it freely as an application directly to the raw surfaces of fresh wounds before closing them, and it has been found not to prevent union by first intention ; but its use in this way is not to be recommended, as it is a needless introduction of a foreign body.

Iodoform possesses very marked toxic properties, but the effect produced seems to depend to a great extent upon an idiosyncrasy on the part of the patient. The symptoms of iodoform poisoning are very various, and differ somewhat in children and adults. Amongst the most marked effects has been an elevation of temperature reaching 104° F., without other serious constitutional disturbance, and without any unhealthy appearances in the wound. Loss of appetite with progressive emaciation is common, the patient complaining that everything tastes and smells of iodoform. Vomiting, however, is not a frequent symptom. The effect on the pulse is often very marked, especially in children ; the frequency is greatly increased, reaching 140 or even 180, and at the same time the force is correspondingly diminished. Its effects on the brain are often very serious ; in some adults it seems to have caused an attack of violent maniacal delirium, in others persistent drowsiness has been noted, with great mental depression. In children drowsiness is more common, and occasionally the symptoms may closely resemble those of tubercular meningitis. In other cases rapid collapse has followed the use of iodoform, for which no cause but the drug could be found. Many fatal cases have occurred in Germany ; but the quantities applied have been in some cases

so enormous that this is scarcely to be wondered at. As an external dressing to a wound, the edges of which have been brought accurately in contact, it has never been known to cause poisoning, though when applied on the raw surface left by a large burn it may give rise to some of the above-mentioned symptoms. The urine, in all cases of iodoform poisoning, has been found to contain iodine. The treatment consists in the immediate and complete removal of the drug, which will usually be followed by speedy disappearance of the symptoms.

Permanganate of Potash, a solution of which forms "Condy's fluid," is a powerful oxidising agent. It possesses very active powers as a disinfectant, destroying the smell of decomposing matter even when used in very dilute solutions. In stronger solutions it is a powerful antiseptic, destroying the vitality even of the spore-bearing bacilli, but in order to do this its strength must be such that it could hardly be used on living tissues. It forms a valuable wash for foul wounds; but if used in sufficient strength to exert really powerful antiseptic influence, it stains everything with which it comes in contact a dark brown. It possesses practically no toxic properties.

Benzoic acid possesses extremely powerful antiseptic properties, but has not been used pure in the treatment of wounds. It forms an important constituent of Compound Tincture of Benzoin, Friar's Balsam, or Wound Balsam, which was formerly extensively employed as an external application to wounds, and is still sometimes applied to compound fractures.

Turpentine was, in former times, a constituent of almost all salves for wounds, and doubtless did excellent service as an antiseptic. At the present time it is scarcely ever used. A highly refined form is sold under the name of *terebene*, which, dissolved in olive oil in the proportion of 1 to 5, forms a useful dressing.

Thymol is the aromatic principle of thyme. It is said to be an efficient antiseptic if dissolved in water in the proportion of 1 in 1000. It is but little irritating and is not poisonous; but it presents few other advantages, and is rarely used except for washing out a cavity, as the rectum, from which carbolic acid might be absorbed in dangerous quantities if injected.

Glycerine possesses decided antiseptic properties, but its efficient strength is uncertain. It is chiefly useful as an addition to boracic or carbolic lotions to prevent them from drying too quickly.

Alcohol.—The antiseptic properties of alcohol are too well known to require mention. It is said to be efficient in the strength of one part in fifty of water, or roughly, one ounce of proof spirit to a pint of water. It is but little used in surgery as an antiseptic, because of its evaporating too rapidly, but it may be employed as a wash for wounds or for the hands and instruments if none more efficient is at hand.

Amongst the most powerful means of preventing inflammation is the free application of **cold**. This causes contraction of the vessels and limits exudation, thus preventing tension and swelling. The cold should not, however, be so intense as seriously to lower the vitality of the injured part, or it may cause the very mischief it is intended to prevent. Its application must moreover be *continuous* till the danger of inflammation is past, for if applied in an intermittent manner, the periods of hyperæmia which occur in the intervals between the cold applications undo whatever good may have been done during the time that the part has been really cooled. If the injury be

superficial, and not very severe, lint dipped in cold water, frequently renewed, may be applied ; or, if the skin be unbroken, an evaporating lotion may be used. Should a limb or joint be severely injured, cold irrigation will be a preferable mode of reducing its temperature. This may most conveniently be done by suspending over the part a large wide-mouthed bottle full of water, in which a few pieces of ice may, if necessary, be put ; one end of a skein of cotton, well wetted, is then allowed to hang in the water, whilst the other end is brought over the side of the bottle. This, acting as a syphon, causes a continual dropping upon the part to which the cold is to be applied (Fig. 85).

But the direct application of pounded ice in a bladder or thin rubber bag is the most effectual means of applying cold, when it is intended that its effects should penetrate deeply, as in an injured joint, spine, or head.

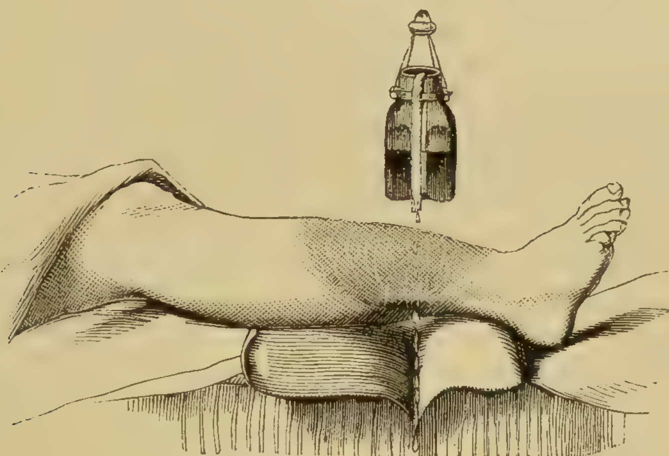


Fig. 85.—Irrigating Apparatus.

Another very efficient mode of applying cold is to surround the part with a coil of India-rubber tubing through which a stream of iced water is allowed slowly to flow from a reservoir placed above the bed. This method was introduced by Otis as a mode of applying cold to the genital organs, and for this purpose it is very efficient. When applied to the head or a limb, the weight of the part is apt to compress the tube and arrest the flow. To overcome this difficulty, the apparatus known as **"Leiter's tubes,"** made of soft metal which can be accurately applied to any part of the body, has been lately introduced. In using this the water must not be iced, as the greater conducting power of the metal renders this not only unnecessary but dangerous.

The application of a cold **Lead Lotion** acts as a powerful local sedative, and tends greatly to restrain local inflammation.

Absolute rest of the parts is an essential element in the preventive treatment of inflammation. Rest as to movement or use is imperative; an injured joint should be placed on a splint, an injured eye should be protected from light.

At the same time all constitutional disturbance must be prevented by a moderate and well-chosen diet, by repose of body, by regulation of the action of the bowels, and by careful attention to the hygienic surroundings of the patient.

In undertaking the **Curative Treatment** of inflammation, the Surgeon must not allow himself to be led away by the name of the affection with which

he has to do, but he must be influenced in the means that he adopts by the constitutional condition of the patient, by the type of the inflammatory fever, and by the state of the diseased part; for nothing presents greater variety than the management of the inflammatory process in different conditions of the patient, and in the different types and phases of the disease. We shall accordingly consider the treatment of acute inflammation as it is accompanied by the sthenic and the asthenic form of inflammatory fever.

Treatment of Acute Inflammation with Fever of the Sthenic Type.—In the treatment of this variety, active and energetic measures must early be had recourse to, especially if the patient be young and strong. There is no condition that is more under the control of the Surgeon than this when it occurs in a healthy constitution, and none in which more can be done by active means early employed. It is consequently of the first importance that precious time be not lost by the employment of inefficient measures; otherwise, important local changes and irremovable alterations of structure may ensue. It is also of great consequence to remove the disease fully; not only to subdue, but to extinguish it, lest it degenerate into some of the more chronic and intractable forms.

The first thing to be attended to in the treatment of this, and of all the other varieties of inflammation, *is the removal of the cause.* Thus, rest must be afforded to a diseased joint, light withheld from an inflamed eye, and a foreign body taken out of the flesh in which it is lodged.

The next great indication is to lessen the determination of blood to the part, and the blood-pressure in the distended vessels. The measures for accomplishing this form what has been termed the *antiphlogistic treatment.* This consists of constitutional and local means.

Constitutional Treatment.—The object aimed at in constitutional antiphlogistic treatment, is to lessen the blood-pressure in the inflamed part by means which weaken the force of the heart's action, or diminish the amount of blood generally throughout the body. It is evident that it is only in patients who have been in good health and strong before the invasion of the inflammation, and who have not been weakened by it, and in young or middle aged subjects, that such treatment can be justifiable. Many forms of inflammation, as erysipelas, and all other infective processes, are from the nature of their cause depressing in themselves; and in these active antiphlogistic treatment is seldom if ever required.

The most powerful and efficient means that we possess is certainly **Blood-letting**; and, when the inflammation is sufficiently extensive and severe, and the state of the patient's powers warrant it, we may have recourse to the abstraction of blood. But, as blood can easily be taken away, but cannot readily be restored, we should never remove it unnecessarily, lest permanent ill effects to the health ensue. Blood-letting is certainly not often required in the treatment of surgical inflammations; and it should be especially avoided in very young and in very old subjects, in the inhabitants of large towns generally, and in persons who are suffering from inflammation of a specific character. It should never be employed unless an organ of great importance to the economy, and one in which abundant exudation is likely to be followed by serious or fatal consequences, as the lung or brain, be inflamed, or so injured that inflammation is imminent; or unless a tissue, like the transparent structure of the eye, be affected, in which case it is absolutely necessary, at any

risk, to limit exudation lest it give rise to a change of structure, which, however slight, would be fatal to the utility of the part. The quantity of blood that should be taken necessarily varies greatly, according to the age and constitution of the patient, and the nature of his disease ; and it is of importance to bear in mind that, when blood-letting is really required, the system tolerates the loss of the vital fluid much better than at other times. The effect produced on the pulse and on the system should be the guide to the quantity to be taken away. A decided impression should be produced by blood-letting, not so much on the frequency of the pulse, as on its character ; *that* should guide us, and not the number of ounces drawn. The point to be obtained is the greatest effect upon the system with the least loss to the patient ; hence the blood should be taken from a large orifice, the patient sitting upright. In repeating the venesection, we must be guided by the impression that has been made upon the disease, and by the state of the pulse. In former times, blood-letting was sometimes practised from the temporal artery, and the external jugular vein ; but in the present day, blood is scarcely ever taken from any vessel but the median basilic vein at the bend of the elbow. The operation is thus performed : the patient being in a sitting posture, a tape or a piece of bandage is bound round the arm about midway between the shoulder and the elbow, with sufficient firmness to obstruct the return of blood through the veins, and yet not to interfere with the flow through the artery. When the limb below the bandage is fully distended with blood, the operator selects the most prominent vein at the bend of the elbow, which will almost invariably be the median basilic, and compresses it with his thumb *below* the point at which it is intended to open it ; this serves the double purpose of steadying the vein, and preventing a premature escape of blood. He then takes the lancet, or any other small, sharp-pointed, cutting instrument if a lancet be not at hand, and, holding it by the blade between the fore-finger and thumb, while he steadies his hand by resting the other fingers on the arm of the patient, he divides the skin and opens the vessel by a single incision about one-third of an inch in length, carried obliquely across the vein and dividing its anterior wall. He then takes a graduated vessel, and, holding it in such a position as to catch the blood, he removes his thumb from the vein, and allows the proper amount to escape. During the operation the patient should hold some round body in his hand, which he can grasp firmly at intervals, by which means the blood from the deep veins is driven out from amongst the muscles into the median by the communicating branch which enters it just before its bifurcation. As soon as a sufficient quantity of blood is drawn, the constricting band on the arm is relaxed ; a pad of lint is applied over the wound, and secured by a few turns of a figure-of-8 bandage. The only accident that can happen during the operation is a wound of the brachial artery, which usually lies immediately beneath the median-basilic vein near the point selected for bleeding. This is avoided by holding the blade of the lancet short and firmly, and supporting the backs of the three inner fingers on the patient's arm ; while by a movement of extension of the wrist, the point of the instrument is made to move in a segment of a circle, and so to open the prominent vein without any risk of penetrating more deeply than is intended. If from inadvertency the patient be bled in the recumbent position, a greater quantity of blood may be removed than is intended before the effect on the pulse is produced.

Bleeding from the external jugular vein should never be performed, as it is accompanied by the danger of entrance of air, and the effect produced differs in no respect from that of bleeding from the arm.

Whether blood-letting be practised or not, we must endeavour to set the secretions free, and in this way to clear the blood of the morbid products accumulated in it. If we can bring about a full action of the liver, with copious bilious evacuations from the bowels or an abundant acid perspiration from the skin, or a copious discharge of urine, we shall diminish the constitutional disturbance and mitigate, if not cut short, the local process. With these objects in view, purgatives, diaphoretics, and diuretics are to be administered.

Purgatives, by causing dilatation of the vessels of the alimentary canal, reduce the blood-pressure in other parts, and this effect is still further increased by the diminution they cause in the general mass of the circulating fluid. Moreover, they clear the intestinal canal, and thus favour digestion and assimilation of food. From the frequency with which diarrhœa is associated with unhealthy inflammatory processes it seems probable that the intestinal tract forms an important channel for the elimination of the products of such inflammations from the blood, and the necessity of maintaining a proper action of the bowels would thus be explained. Experience teaches us also that in inflammatory affections constipation always aggravates the elevation of temperature, and a brisk purgative will often bring it down one or two degrees. This is especially the case with children. Purgatives should, therefore, always be given early, except in some special cases of acute inflammation of the abdominal organs. In general, it will be found most advantageous to administer a mercurial, followed by a brisk saline purge ; and this should be repeated from time to time during the progress of the case.

Diuretics and Diaphoretics are of much use when fever forms a marked feature of the case, and they should then be administered frequently during the day. Free perspiration lowers the temperature by increasing the loss of heat from the surface of the body and the dilatation of the cutaneous vessels tends to diminish the blood-pressure in internal parts. Both the skin and kidneys also take an important part in the elimination of the products of the increased tissue-change which forms an essential feature in the febrile process ; and, unless both perform their functions properly, these products may accumulate to a dangerous extent. The diaphoretics and diuretics most commonly used are citrate of potash, acetate of ammonia and nitrate of potash. If the skin be hot and dry, small quantities of antimony may be administered either in the form of antimonial wine conjoined with the salines above-mentioned, or as James's powder combined with Dover's powder. Antimony is best given in small repeated doses, but if it be pushed too far, so as to induce distinct nausea, it exerts a powerful depressing action on the heart, and consequently its effects must always be carefully watched.

Aconite in small doses frequently repeated—one minim of the tincture every half hour for four hours and then every hour—exercises a most marked influence on simple inflammatory fever with high temperature, but with no visceral complications. It lowers the force and frequency of the pulse, and produces speedy and copious sweating, to the infinite relief of the patient.

In many forms of acute inflammation, especially those which affect the serous and fibrous membranes, we do not possess a more efficient agent

than **mercury**, administered, not as a purgative, but as an alterative to the system. And I confess that I can in no way give my adherence to the doctrines of those who, disregarding the daily evidence of professional experience, deny the utility of the preparations of this mineral in the treatment of certain forms of inflammatory disease. Mercurial remedies are of special service in aiding the operation of other medicines. Diuretics, diaphoretics, and purgatives, will frequently not act properly unless conjoined with a mercurial. In inflammation, the preparations of mercury are of especial value in promoting the absorption of exudation-matters, as we may see happening under their influence in certain diseases of the eye. Care, however, is required in the administration of mercury. In irritable or cachetic constitutions it should not be given at all, or not without great caution. It is best borne by strong constitutions, and in acute inflammation of the serous and fibrous tissues.

Calomel, blue pill, and powder of mercury with chalk, are the preparations usually employed when the mineral is given by the mouth. When it is administered endermically the mercurial ointment is preferred. The mercury need never be pushed to salivation, but in some cases it may be given until the gums are slightly affected.

It is especially the combination of **calomel with opium** that produces the most beneficial effects in the treatment of active surgical inflammation. Half to one grain of calomel, and half a grain or a grain of opium, or five grains of Dover's powder with three of mercury and chalk, every sixth or eighth hour, tranquillise the system and diminish the force of the heart's action in a remarkable manner, especially in acute inflammation affecting the joints, the eye, or the serous membranes.

Opium is of use not only in the way that has just been indicated, but is of essential service in allaying the pain and irritability that often accompany inflammation, especially in many inflammatory affections of the bones and joints. In the form of Dover's powder, it is of especial value in this respect, and in this form, alone or combined with James's powder, it forms one of the most powerful diaphoretics we possess.

The hypodermic injection of morphia, invaluable as it is in assuaging pain, is seldom required in the treatment of acute inflammation. Opium combined with ipecacuanha and a mercurial is preferable.

In the treatment of acute inflammation, it is of essential consequence that the patient should be kept at rest, in an atmosphere of well-regulated temperature, and on low diet; in fact, the more complete the abstinence in this respect, the more rapidly do therapeutic agents act and the febrile symptoms cease.

Local Treatment.—This is of the utmost importance, as it directly influences the tissues and vessels that are deranged in action. It consists of means of the most varied and opposite characters. Heat and cold; iced water and hot fomentations; astringents and sedatives—are all employed, and all with success, but each only in certain stages and forms of the disease; and the art of conducting the local treatment of inflammation consists in adapting the various means at our disposal to the particular conditions of the case before us.

Local Blood-letting is the most efficient means we possess of directly lessening the amount of blood in an inflamed part, as by it in some cases we

take blood directly from the distended and engorged vessels. It does not always act, however, quite so simply as this. In no disease is the benefit of local blood-letting more marked than in acute inflammation of the middle ear, and yet in this case we draw the blood from the cutaneous vessels over the mastoid process. In acute orchitis relief is often given by puncturing the distended veins of the scrotum, which have no direct connection with the swollen gland. In these cases the relief is, perhaps, due to a reflex contraction of the arteries leading to the inflamed part.

Local blood-letting may be used in addition to, though it is most commonly employed in preference to, general blood-letting, especially if the inflammation be not severe, or if it occur at either of the extremes of life, in women, and in persons of generally feeble power.

Blood may be taken locally by *punctures*, *scarifications*, or *incisions*, or by *leeching* or *cupping*.

Punctures, scarifications, and **incisions** can be practised only in inflammation of the cutaneous and exposed mucous surfaces, due attention being paid to subjacent parts of importance. They constitute a very efficient means of relieving the part, as not only is blood removed, but an exit is afforded for effused matters ; tension is consequently materially lessened, and the tendency to sloughing and other evil after-effects perhaps prevented. The removal of the tension of inflamed parts is not only of the greatest advantage locally, but is of considerable service to the system at large by lessening the pain and general irritation that are always occasioned by it. **Punctures** should be made with a fine lancet, in parallel rows over the inflamed surface, and should not exceed a quarter of an inch in depth. **Scarifications** are in reality small and short incisions. They may be made across swollen and congested vessels, which will bleed freely, as in the relief of a chemosis of the lower eyelid. A modification of puncture is sometimes practised by opening the veins in the neighbourhood of the inflamed part at several points at once. Thus, in inflammation of the testis, the scrotal veins may be punctured with advantage.

When **incisions** are required they must always be made in the axis of the limb, and should be so arranged as to afford the greatest possible relief to the tension. Their length and their depth must vary according to the seat of the inflammation. Thus in the inflamed conjunctiva they must of course be very limited, whilst in phlegmonous inflammation of a limb they may be of much greater extent and depth. Care must be taken as far as possible not to wound superficial arteries or veins of sufficient size to bleed dangerously. Bleeding from punctures and incisions may be encouraged by warm fomentations.

Leeches are usefully applied to the neighbourhood of inflamed parts, but should not be put upon the inflamed surface itself, as their bites irritate. There are certain situations in which leeches should not be placed, as over a large subcutaneous vein, or in regions where there is much loose areolar tissue, as the scrotum or eyelids, lest troublesome hæmorrhage or ecchymosis occur. So, also, they should not be applied near a specific ulcer, lest the bites become inoculated by the discharge. The bleeding from a leech-bite may be encouraged by warm poulticing or fomentations for some time after the animal has dropped off. In this way from half an ounce to an ounce of blood may be taken by each leech. There is usually no difficulty in arresting the hæmor-

rhage from the bite; should there be any difficulty, continued pressure with some scraped lint, felt, matico, or powdered alum, will generally succeed. If this do not, which may happen in some situations where pressure cannot be conveniently applied, as on the neck and abdomen, particularly in young children, a piece of nitrate of silver scraped to a point, or a heated wire, introduced into the bite, previously wiped dry, or a needle with a twisted suture over and around it, may be required.

Cupping may be either "wet" or "dry"; dry cupping consists of the application of the cupping glasses to the skin without making any previous scarifications. It is a means of causing a determination of blood to the surface for the purpose of diminishing the flow to an internal organ. Thus in congestion of the kidneys following an operation on the urethra or bladder, dry cupping in the loins is often of considerable use. It is employed especially in those patients whose constitutional state does not justify the abstraction of blood. The instruments required are a spirit lamp with a large flame, and the cupping glasses. These are made of thick glass and are dome-shaped with smoothly-ground edges. The operation consists merely of rarifying the air in the cupping glass by means of the flame of the spirit lamp, and instantly applying the glass firmly and evenly to the skin. The intention is not to heat the glass but the air contained in it, and in fact to a great extent to replace the air by the products of combustion of the flame of the lamp. It is for this reason that a large flame completely filling the glass should be used. If the operation be properly performed the site of the glass will be marked by a bruise due to the rupture of the capillary vessels in the area included in the vacuum.

In wet cupping the glass is applied in the same way over a number of superficial incisions which are made instantaneously by the "scarificator," an instrument provided with a number of parallel knives worked by a spring and released by a trigger. The quantity of blood extracted is regulated by the size of the glass, and the flow from the superficial wound ceases the moment it is removed. Cupping cannot, however, be employed upon the inflamed surface itself, on account of the pain and irritation that it would occasion, and is consequently chiefly applicable to internal inflammations. As the scars made by the scarificators continue through life, cupping should not be practised upon exposed surfaces.

Cutting off the Supply of Blood from the inflamed part by the ligature of the main artery leading to it has been adopted in some cases. Thus, in acute inflammation of a joint, the main artery of the limb has been tied—the femoral, for instance, in inflammation of the knee-joint. By many Surgeons, and by most patients, the remedy would be considered far worse than the disease for the cure of which it is proposed.

Vanzetti has recommended digital pressure on the arteries in inflammation. He has, for instance, related a case of severe acute inflammation of the hand, relieved by twenty-four hours' continuous pressure on the brachial artery. Neudörfer speaks highly of the proceeding, which he regards as surpassing all others in efficacy, rendering even unnecessary the ordinary antiphlogistic treatment. He recommends intermittent pressure for not less than three, and not more than eight, minutes three or four times a day. The method is applicable to inflammation of any part of which the artery is within reach; and, though we may not go so far with Neudörfer as to suppose that it obviates all

necessity for constitutional treatment, it appears to be a remedy preferable in many cases to local blood-letting.

In *Cold* and *Heat* we possess two most important local means of controlling inflammation. They cannot, however, be employed indiscriminately.

Cold.—The use of cold in the prevention of inflammation has been already described (p. 196). When inflammation is fully established with its cardinal symptoms of redness, swelling, heat, and pain, cold can scarcely be applied without doing harm; as, although it may lead to a diminished flow of blood to the part by causing contraction of the arteries, it tends still further to lower the vitality of the affected tissues, and thus to increase the adhesion of the corpuscles and the retardation of the flow, till stasis, followed by death of the part, may result. Cold should never be had recourse to when suppuration is coming on or has set in; still less should it be employed when there is a tendency to mortification. The modes of applying cold have already been described (p. 197).

When acute inflammation has passed off and the vessels of the part remain relaxed and turgid, the application of cold is often a powerful agent in restoring the tone of the parts. For this purpose cold salt-water douching or sponging is the most efficacious.

Warmth and moisture, conjoined, are of the utmost service in the treatment of inflammation during the height of that process—during that period when cold applications are not admissible. By these means, tension is relaxed, effusion is favoured, and the over-distended vessels are relieved. Warm applications are especially serviceable in all cases of inflammation attended by much pain, more particularly if this occur from tension; and they are particularly useful when suppuration is threatening, or has come on, and in many cases in which there is a tendency to sloughing.

When abscess threatens, and the skin is not broken, nothing affords so much relief as a well-made **linseed-meal poultice.** To make this smooth and soft, the meal must be gradually added to the proper amount of boiling water, being vigorously stirred at the same time. If the water be added to the meal, the mass is apt to become lumpy. It must be spread, not too thickly, on a piece of linen-rag, and applied as hot as the patient can bear it. It is better to use meal from which the oil has not been expressed, or to add to the ordinary linseed meal a small quantity of olive oil, which prevents its drying and sticking to the skin. But, useful as poultices are for the relief of tensive pain, or the hastening of suppuration when applied to the unbroken surface, they are most objectionable when applied to a wound, ulcer, or granulating surface. Then they merely encourage putrefaction. In such cases **wet dressing**, consisting of a double or triple layer of lint, well soaked in a warm solution of carbolic acid, or boracic-acid-lint moistened with a hot solution of boracic acid, may be applied and covered by oiled silk, extending half an inch to an inch beyond it on all sides. This may be covered with a thick layer of cotton-wool secured by a bandage. By these means we obtain an application which is cleaner and lighter than a poultice, and which retains its heat equally long.

Fomentations of warm water, or of decoction of poppy and camomile flowers, applied by means of flannels wrung out of these liquids, or of bags containing the boiled plants, well soaked in the decoction, squeezed out, and applied hot, are very useful in extensive superficial inflammations. The

flannels and bags should be well covered with oiled silk or rubber cloth, so as to retain the heat, and to prevent evaporation. Spongio-piline may be used as a substitute for ordinary fomentations, in cases in which the surface is unbroken.

Dry cotton-wool heated before a fire, applied warm, and covered with a large sheet of oiled silk, may sometimes be conveniently substituted for a fomentation. The watery vapour given off from the skin being enclosed by the oiled silk forms a sort of warm vapour bath for the affected part. Dry heat in the form of flannels, or bags of bran toasted before the fire or heated in an oven, are often convenient applications, especially for the head or abdomen.

Belladonna, applied externally, exercises a very distinct and rapid controlling influence over superficial inflammations of an acute and spreading character. It is supposed to act partly by causing contraction of the muscular coats of the small arteries by its direct action on the vaso-motor nerves, and partly by its sedative effect on the cutaneous sensory nerves, stimulation of which, as we have before seen, causes by reflex action a dilatation of the vessels in the area irritated. It is best applied as a paint composed of equal parts of the extract and of glycerine, which may be smeared on the inflamed part and covered by cotton-wool, or hot fomentations may be put on over it with the greatest advantage. There need be no fear of producing symptoms of belladonna poisoning, even when large surfaces are painted with the extract and glycerine. I have frequently painted the whole arm in this way without any unpleasant effect ; and the most I have ever noticed has been a little dryness of the throat after some days' use of the drug. The belladonna and glycerine must be carefully kept out of the way of children, as its taste is not unpleasant, and they are very likely to eat it by mistake for treacle. Two such cases have been lately admitted into University College Hospital, both of which fortunately recovered.

Position and Rest.—The inflamed part should when possible be placed in such a position as to facilitate the return of blood from it. Unless this be done, the pain is greatly increased, and the congestion augmented. Hence the part requires to be elevated to a level with, or above, the rest of the body. All motion and use of the part must likewise be interdicted, and, if necessary, restrained by splints or other appliances.

These are the means by which acute, active inflammation is arrested and cured. In their employment, we must endeavour to proportion the activity of our measures to the age, constitution, and vigour of the patient, and to the seat and intensity of the local disease ; and must continue the treatment until the inflammatory process is not only arrested, but has entirely subsided, the part being restored to its ordinary healthy state.

Treatment of Acute Inflammation with Constitutional Symptoms of the Asthenic Type.—This form of inflammation derives its peculiarities from the character of the constitutional disturbance, rather than from any peculiarity in the local affection. Hence it is in the management of the constitutional condition that the principal difference exists between the treatment of this and that of the other varieties of acute inflammation.

In considering this part of our subject, it is of especial importance to banish the term "*antiphlogistic* ;" for the same treatment that would arrest inflammation in one form of the disease, would certainly favour its progress in

another. Nothing appears to me to be more unscientific than to endeavour to treat all inflammations on one uniform plan. Surely the scoffers at medical science have some ground for doubting at least the wisdom of its Professors, when they see one set of practitioners treating every inflammatory disease with depletion, antimony, and calomel, whilst others teach that the panacea for all inflammations consists in brandy, ammonia, and bark. It is impossible that both methods can be right, as exclusive plans of treatment. But the error lies in making them exclusive. Each is serviceable in, and indeed applicable only to, its own particular cases. And between these extremes lie a multitude of forms of disease, in which endless modifications and combinations of these two methods of treatment—the stimulating and the depletory—must be adopted by the Surgeon in order to meet the varying conditions of his patient. The local symptoms that accompany the inflammatory process, whether occurring externally or internally, in the conjunctiva or in the lung, are associated with constitutional disturbance that varies according to the age and the constitutional condition of the patient. It is the type assumed by this constitutional disturbance, its sthenic or its adynamic character, as indicated by the general condition, by the pulse, and by the tongue, and not the mere local disease, that must guide the Surgeon in the adoption of his line of practice. We may advantageously treat with antimony and blood-letting acute inflammation of the eye, or that which is the consequence of a wound of the lung, in an otherwise healthy and robust man of thirty; whilst in a broken man of seventy, ammonia, bark, port wine and brandy would be equally proper; but if we were (except under peculiar and unusual circumstances) to reverse this treatment—to stimulate the young or vigorous, and to deplete the aged or feeble—we should act contrary to common sense, and probably destroy rather than cure our patients. It is of far greater importance to be able to estimate accurately the true constitutional condition of the patient, than to be able to form a minute diagnosis of the precise seat, extent, and depth of the local mischief. It is a fatal error, too often committed, to attach the chief importance to the detection of the local malady, and to regard the recognition of the character of the accompanying constitutional disturbance as of minor interest. The Surgeon, who acts thus, runs the risk of treating the Name and not the Disease. If we treat erysipelas or pneumonia as mere affections of the skin or of the lung, on one uniform plan, without reference to the type of the constitutional disturbance accompanying them, we shall miserably err in a large proportion of the cases. But if we make the constitution of the patient our guide, and deplete or stimulate accordingly—even though we treat two patients with the same disease, so far as name is concerned, on totally opposite plans—we shall not act inconsistently, but in strict conformity with the natural condition of the patient and of his disease.

We must be guided in the means that we adopt entirely by the condition of the patient, the state of the tongue and pulse, and the general character of the symptoms. If these from the first partake of the asthenic type, we cannot at any period have recourse to the treatment that has been recommended in inflammations accompanied by sthenic fever. If the disease commence in an active form, the fever progressively assuming a lower and lower character, merging into the asthenic type, so must we gradually modify the nature of our general treatment. This, however, is always a delicate procedure, requiring much caution. Though the inflammatory fever may at first assume the sthenic

form, if there be reason to believe, from the broken constitution of the patient, or from the character of the local inflammation, that the constitutional symptoms will not long continue of this type, we must be extremely cautious how we lower the patient by active depletion; for, however high the fever may at first run (and in these cases there is often febrile disturbance of a very active character for the first few days), the disease speedily expends its force and rapidly subsides into a low form. In cases of this kind, which are of very common occurrence in London practice, more particularly in hospitals, we should never bleed, but content ourselves, after clearing out the bowels, with keeping the patient quiet on a moderately low diet, and administering diaphoretic salines. As the symptoms gradually merge into the typhoid type, the pulse increasing in frequency, but diminishing in power, the tongue becoming dry and dark, and the other symptoms of asthenia beginning to show themselves, we must begin to give some stimulant in combination with the salines. The carbonate of ammonia in three to five grain doses, or even more, may be given with bark, or in an effervescent form with bicarbonate of potash and citric acid, every third or fourth hour. A convenient form of this mixture is fifteen grains of bicarbonate of potash and an equal quantity of carbonate of ammonia, and twenty-five grains of citric acid. These must be thoroughly dissolved, the citric acid in one glass, and the alkaline carbonates in another, each containing about four ounces of water. The two solutions may then be mixed and taken whilst effervescing. The nourishment must be increased; and wine or alcoholic stimulants must be conjoined with it, in proportion as the symptoms of debility become more and more marked. In effecting this change, however, we must be careful not to run into the error of over-stimulating our patient; this may be avoided by observing the influence exercised on the pulse and tongue and temperature by the change in treatment.

In the majority of cases, this stimulating plan is not well borne during the first few days after the setting in of an inflammation, especially if there be gastric irritation and sickness; but when the more active symptoms show a tendency to subside, when the bowels have been well cleared out, and the skin is beginning to assume a slight degree of moisture, then it may be resorted to with every probability of success.

But it may happen that the symptoms so rapidly sink into an asthenic character, or from the very first assume it, that the only treatment which holds out a prospect of saving the patient's life consists in the early and free administration of tonics and stimulants, with mild nourishment, such as ammonia and bark, wine, brandy, or porter, with beef-tea and arrowroot; and of these, large quantities may be required in the four-and-twenty hours, the patient evincing a tendency to sink whenever their use is interrupted. Although stimulants be freely administered in these cases, the food should be bland and capable of easy assimilation. It is worse than useless to give meat, &c., when the patient cannot digest it; but beef-tea, eggs, and farinaceous food, may be given in large quantities with advantage. The brandy-and-egg mixture of the Pharmacopœia, if well made, combining nutriment and stimulus, is the best remedy that can be administered in many cases.

Under this plan of treatment the tongue will be found to become moist, the brown sordes to clear off from the inside of the mouth, the pulse to become steady and full, the temperature to fall, sleep to be procured, and the strength

maintained. If there be much delirium and restlessness, we may find it necessary to combine opiates with the general treatment.

In the low forms of inflammatory fever, congestive pneumonia and bronchitis frequently supervene. In this complication, the following draught may be advantageously given every third or fourth hour:—℞ Tincturæ Camphoræ comp. ♏ xx. ad xxx., Ammoniæ Carbonatis gr. v., Decocti Senegæ ℥ iss. Rubefacients, blisters, or dry cupping may also be applied to the chest. The diarrhœa that not unfrequently occurs must be met with opiates and astringents; and if the urine cannot be passed, it must be drawn off by the catheter.

The more I see of inflammatory fever, the more confidence do I feel in this stimulating plan of treatment, which is the only method of successfully carrying patients through the disease should it assume the asthenic type. Fortunately, though its treatment is not, in many cases, as satisfactory as we could wish, its prevention has of late years come to be much better understood. In a certain proportion of cases the constitutional state of the patient is such that any inflammatory process will certainly assume this type, but in the majority of cases, the special constitutional state is secondary to an unhealthy septic or infective process going on in the seat of inflammation. By the prevention of these unhealthy processes by the modern treatment of wounds, and by the improvement of the general hygienic conditions of our hospitals, much has been done to prevent the occurrence of the worst form of asthenic inflammatory fever.

CHRONIC INFLAMMATION.

The preceding description has referred solely to acute inflammation, and it now remains to give a brief summary of the distinctive characters of the chronic form of the process and to describe its treatment.

Chronic inflammation, although it differs in its course, symptoms, and effects from the acute form, is but a modification of the same process. In acute inflammations, the essential features are a diminution of the vital activity of the walls of the vessels and the surrounding tissues, dilatation of the vessels, with exudation and infiltration of the affected area with new cells, accompanied by changes of a degenerative or destructive character in the original tissues of the part. In chronic inflammation all these phenomena are met with, but in a lower degree and less strongly marked, and it will be most convenient to consider them in the same order as in the acute process.

The dilatation of the vessels and determination of blood is much less. The chronic distension, however, lasting as it may do for an indefinite period, leads to a permanent loss of tone and dilatation, especially in the small veins, which, in chronically inflamed parts, can often be seen clearly with the naked eye. The relaxation of the arteries is less complete, and there is often a tendency to slackened circulation. The redness of chronic inflammation is therefore as a rule more dusky than that of acute. The whole process being due to a slighter degree of irritation, the impairment of vitality in the vascular walls is not so great, and the tendency of the corpuscles to adhere and migrate is consequently much less. Migration, however, does occur, but not to the extent nor with the rapidity observed in acute inflammation. The exudation that accompanies the migration is in the majority of cases less rich in albumen and in the constituents of fibrin than that which escapes in acute inflammation, as the vessels, though allowing more liquid than natural

to exude, have still sufficient vitality remaining to exert a selective influence on what passes through their walls. Thus in chronic inflammations of serous or synovial cavities, we frequently find them distended with a fluid of considerably lower specific gravity than that of the liquor sanguinis, and not possessing the power of spontaneous coagulation.

The tissues of a part affected by chronic inflammation become, as in the acute process, infiltrated by new cells. In the acute process, it may now be said to be proved that all these cells are white corpuscles that have migrated from the vessels, and possibly multiplied by division in their new situation. In chronic inflammation, although migration does take place, it is doubtful whether some of the new cells may not be derived from multiplication of the original connective-tissue-corpuscles of the part. In very chronic processes in which the impairment of vitality is slight, this does not seem impossible. Be that as it may, the new cells which appear may undergo a variety of changes according to circumstances. If the part recovers, they may, as in acute inflammation, disappear, either finding their way back into the vessels or undergoing disintegration and absorption. In other cases, they may become heaped up, slowly destroying or displacing the surrounding tissues till they form a mass, often of considerable size, as in chronic inflammations of the synovial membranes of joints; in these masses of cells new vessels are formed, but the vascularization of the new growth is always more or less imperfect, so that degenerative changes early set in for want of sufficient supply of nutriment. Thus, in chronic inflammation of joints, we may find, replacing the synovial membrane, a soft pulpy mass of tissue, perhaps an inch in thickness. The layer of this, in nearest relation to the vessels of the surrounding healthy structures, is moderately supplied with new vessels, and presents the ordinary appearances of healthy granulation-tissue; next to this is a layer containing few vessels, and here masses of protoplasm containing many nuclei are often met with. Lastly, we find a layer in which the cells have perished from want of blood supply. If they are still recognizable as cells, they are withered and shrunken and filled with fat-granules; but usually they are in part at least reduced to a granular mass, in which no individual elements are any longer to be seen. This fatty layer may soften and break down into a fluid, which somewhat resembles pus in appearance, but on microscopic examination is found to contain few, if any, pus-cells. The collection of fluid thus formed is called a *chronic* or *cold abscess*.

Another fate that may befall the accumulations of cells formed as a consequence of chronic inflammation is, that after undergoing complete fatty degeneration, the mass so formed may become dry and cheesy by the absorption of its fluids. The caseous masses thus formed may remain in this state for an indefinite period, but at any time they may soften from causes as yet but imperfectly understood. In the process of softening, the cheesy matter undergoes chemical changes which give it irritating properties; and, as the result of this, inflammation of a more acute character with suppuration may be set up, leading to ulceration in the tissue surrounding it, or to the formation of an abscess which finds its way to the surface, and thus the caseous matter may be eliminated from the body.

Another change, the reverse of softening, may take place, when the mass is of small size; it may shrink and dry up more completely, and lime-salts may be deposited in it, forming a chalky concretion, which remains permanently

unchangeable and harmless. Chronic inflammation, with caseation of the inflammatory products and the after-changes of softening, are of frequent occurrence in lymphatic glands, bones, and the subcutaneous tissue ; calcification is occasionally met with in bone, and is very common in the lymphatic glands.

Chronic inflammation gives rise to yet another change, differing essentially from those already described, viz., to an overgrowth of the connective tissue of the affected part. This forms the most marked feature of many forms of chronic inflammation, as in chronic interstitial inflammation of glandular organs, chronic osteitis and periostitis, chronic arteritis, and chronic inflammatory affections of the skin. Many of these affections are so far removed from inflammation in their clinical features, that some pathologists have hesitated to apply that term to them. But they resemble inflammation in being the result of irritation, and in being characterised by a diminished vitality of the affected part, as indicated by the readiness with which a slight injury converts the chronic process into an acute inflammation of the ordinary type. Microscopic examination of tissues or organs from different cases affected in this way, shows every possible variation between the infiltration of the connective tissue with innumerable new cells indistinguishable from the wandering leucocytes of acute inflammation, and probably identical with them, and the development of a tissue composed of dense rigid-looking fibres between which are found a few elongated cells. In fact, no sharp line can be drawn between acute interstitial inflammation and the chronic form with fibroid induration. In bone, chronic inflammation of this type is shown by thickening of the periosteum and formation of new bone beneath it, by increased density of the compact tissue, with narrowing or obliteration of the Haversian canals, or by condensation of the cancellous tissue. In arteries, the growth takes place chiefly from the outer layer of the inner coat, and the new tissue closely resembles the old in structure.

The exact origin of the new tissue has never been conclusively proved ; whether migrating leucocytes take the chief or any part in its production may still be considered an open question ; that in some cases, at least, the new tissue is formed from the old seems almost beyond a doubt.

Another common effect of chronic inflammation is ulceration. Except in the slowness of its progress it differs in no respect from that occurring in acute inflammation. The tissues first become infiltrated with leucocytes, which accumulate and press on the original structures, finally destroying them and taking their place. Then in their turn the destroying cells perish, break down, and come away mixed with serous exudation as pus ; and thus a gradual progressive destruction of tissue takes place. Suppuration of the ordinary type often assumes a chronic form, as in the case of large abscesses proceeding from the thorax or abdomen, or from deeply-seated diseased joints or bones. The natural tendency of all abscesses as soon as they are opened, is to fill up with granulation-tissue and to close ; but when there is some source of irritation present, as decomposing matter, tension from imperfect drainage, or friction of one surface against another, the granulations break down into pus as quickly as they grow, and the process may thus be prolonged indefinitely, the only limit being the powers of endurance of the patient.

In chronic inflammations, although the connective tissue may, as before described, undergo an increased development, the higher tissues always suffer

degenerative changes—partly as a result of the pressure to which they are exposed from the new growth. Thus the tubules or acini of a chronically inflamed gland become obliterated, and muscular fibre undergoes fatty degeneration. In this way the functional activity of organs suffering from chronic inflammation is more or less interfered with. The condition known as catarrh, or catarrhal inflammation, possesses so many special features that it will be better discussed separately.

Thus we see that chronic inflammation, although differing widely from acute, is in reality an analogous process. The development of increased connective tissue is analogous to the adhesive or productive form of acute inflammation, and the formation of a cheesy centre, or a chronic abscess, differs merely in its chronicity from the process by which an acute abscess arises, while ulceration and some forms of suppuration are the same processes in both forms of inflammation, differing only in their rate of progress and duration. Even infective processes may assume the chronic form, as in the general tubercular infection from a softening cheesy centre, in glanders, and in some forms of chronic pyæmia. No sharp line can be drawn between chronic and acute inflammations; and the term "**subacute**" is often used to signify processes in the border-land between the two.

Causes.—The causes of chronic inflammation are like those of the acute process, predisposing and determining. The **predisposing causes** are the same as those of acute inflammation; anything that tends to lower the vitality and interfere with healthy nutrition, either generally or locally, predisposes to one as much as to the other. Perhaps *passive congestion* forms the most common of all predisposing causes, and it is often difficult to draw a distinct line between the non-inflammatory changes, the induration and pigmentation resulting from congestion, and those produced by true chronic inflammation. Certain congenital or hereditary constitutional states form important predisposing causes; the most marked of these being *the scrofulous diathesis*, in which chronic inflammations, especially of the glands, bones and joints are very common. Amongst the acquired constitutional conditions, *syphilis, rheumatism* and *gout* form frequent predisposing causes; so much so, that in all chronic inflammations it is the duty of the Surgeon to bear in mind the possibility of one of these being present. The importance of the predisposing causes is undoubtedly relatively greater in the chronic than in the acute forms of the inflammatory process, and this fact must be borne in mind in the treatment of the affection.

The **immediate causes** of chronic inflammation are of the same nature as those of the acute process, but they act with a less degree of intensity and more continuously. So long as the cause of the inflammation is present the process cannot subside. In chronic inflammation it often happens that the cause which starts the process is of a temporary character, the persistent effect being due to other causes which come into play at a later period. Thus in a common ulcer of the leg the history of the case is frequently as follows. The patient, possibly ill-nourished and feeble from want of proper food, suffers from varicose veins, which interfere with the return of blood from the skin of the leg, giving rise to a condition of passive congestion. As a result of this the skin of the leg is badly nourished and of low vitality, and incapable of withstanding the effects of even mild degrees of irritation. Sooner or later some slight injury, such as a scratch or blow, which would be harmless to

healthy tissues, gives rise to inflammation of sufficient intensity to reach the stage of suppuration. The pus raises the cuticle, forming a small pustule which bursts, leaving a raw surface beneath. The discharge decomposes and irritates the surface, the clothes rub the ulcer, the muscles working beneath in walking move it about, the dilatation of the vessels and the exudation, added to the obstruction in front which originally gave rise to the congestion, produce tension; and all these causes combined, maintain the inflammatory process, the suppuration continues, and the sore slowly spreads by ulceration. In such a case as this the predisposing cause, and the secondary causes, play far the most important part, and the exciting cause that started the process may be so slight as almost to escape notice.

In many cases the nature or quantity of inflammatory products serves partly as a cause of the persistence of the process. Thus in the case of inflammation of the synovial or serous membranes, the tension caused by the effusion of fluid is sufficient to maintain the inflammatory process long after the original cause of mischief has been removed. In other cases, in which formation of new tissue is an important element in the process, the feebleness of the new growth, its imperfect development, or its insufficient vascularisation make it unable to withstand slight sources of irritation; and thus causes which would be harmless to healthy tissues perpetuate the inflammatory process in the new growth; or the new tissue may perish and, acting as a foreign body, excite inflammation in the tissues in contact with it. This we see well illustrated in the condition known as white swelling of a joint. As the result of some slight injury in an unhealthy subject, inflammation is set up and reaches the stage of cell-infiltration of the synovial membrane, and the formation upon it of a layer of granulation-tissue. This feeble tissue gradually increases in quantity till the whole synovial cavity may be filled with it, the tension caused by its presence and the movement of the joint being sufficient to perpetuate the process. Finally, parts of the growth may degenerate and soften, and thus acquire chemically irritating properties, and aggravate the mischief.

Phenomena.—The modifications of colour, size, sensation, function and temperature, described as attendant on acute inflammation, are present also in chronic inflammation; differing, however, in origin and in degree, and often in order and combination. The *colour* is not always changed, unless the part affected be very superficial; and the redness is rather of the dull than of the bright hue, not depending on the rapid transmission of an increased quantity of bright blood, but rather on a congestive condition. The affected tissue may become permanently discoloured by the escape of large numbers of red blood-corpuscles, which break up and are imperfectly absorbed, leaving the pigment behind. The *pain* is not often spontaneously acute, but partakes generally of the character of tenderness, being elicited only by pressure: sometimes, however, the pain is very severe. The increase of *temperature* is usually wanting, and is never great. *Swelling* is an early and most important sign in chronic inflammation. It depends less on the enlargement of the vessels than on the effusion which takes place, and the production of new tissue which often constitutes the distinctive characteristic of the disease.

Like acute inflammation, the chronic form of the disease may be attended by *suppuration*. (See CHRONIC ABSCESS.)

CONSTITUTIONAL SYMPTOMS.—These are less marked in chronic than in

acute inflammation. The patient is in most cases, however, in impaired health; being, in many instances, affected with some constitutional taint which has had its influence in producing or maintaining the chronic character of the inflammation. If an important organ be affected, or if the chronic inflammation, though affecting parts not essential to life, be very extensive, the pulse will be found to be habitually above the normal standard, and exacerbations of fever, often of a distinctly periodic character, develop themselves. In these cases the temperature, as indicated by the Clinical Thermometer, should be closely watched, and a rise towards evening especially noted as an important indication of smouldering fever.

Treatment.—The treatment of chronic inflammation is far more difficult, and requires much more attention, than that of the acute form of the disease. Chronic inflammation is so frequently complicated with various unhealthy conditions of the system, and with an impaired state of the general health, by which, indeed, it is often kept up, that much practical tact and skill are required in carrying out the therapeutic indications properly.

Constitutional Treatment of Chronic Inflammation.—In the treatment of chronic inflammation we have not so much to subdue inflammatory action, as to remove structural changes and other effects induced by it. Hence, our object is not to produce a great and sudden impression on the system, as we are often required to do in the treatment of the acute affection. It is not in this way that chronic inflammation can ever be cured, or its effects removed. The patient might be bled almost to death, and still the diseased action would go on in the inflamed part. It is true that the same antiphlogistic means are employed in arresting the chronic as in cutting short the acute form of the disease, but they are used in a less energetic manner; our object being to induce a gradual and continuous improvement in the state of the system and of the diseased part. Local nutrition is always deeply modified in chronic inflammation; and it can be restored to its normal condition only by improving the patient's general health, and at the same time producing an impression on the part itself by appropriate topical means. Hence, in the treatment of chronic inflammation, hygienic measures are of the first consequence. In most cases, nothing can be done without proper attention to these; and much can be done by these that cannot be effected by any more direct medicinal means. The treatment of this form of inflammation must likewise be varied according as it is uncomplicated, occurring in an otherwise healthy constitution; or as it assumes a congestive or passive character in a cachectic and feeble system; or as it is met with, affecting a specific form, in an unhealthy constitution.

In the management of these various forms of chronic inflammation the patient must be kept at rest, and, if the disease be at all extensive, confined to bed. He should be in pure air, and, as a general rule, have a light and unstimulating diet. The regulation of the **diet** is of much consequence, and the amount and quality of the nourishment afforded must be carefully proportioned to the age, strength, and previous habits of the patient, as well as to the degree and the seat of the inflammation, and the form of constitutional fever that accompanies it. In the more active form of chronic inflammation, farinaceous slops, at most beef-tea, and light puddings, can alone be allowed, In the less active forms occurring in feeble constitutions, with depression of general power, animal food of a light kind may be given, and the scale of

nourishment increased until stimulants, as beer, wine, or brandy, are allowed. Nothing requires greater nicety in practice than to proportion the diet, and to determine the cases in which stimulants are necessary. It may be stated generally that, the more the disease assumes the asthenic and passive form, the more are stimulants required ; until, at last, in the truly adynamic type, our principal trust is in these agents, and large quantities of wine, brandy, and ammonia are required to maintain life.

Mercury is of essential service in the more active forms of chronic inflammation ; but in all cachectic and strumous constitutions it should, as much as possible, be avoided. It is of great use not only in arresting the further progress of the disease, but especially in causing the absorption of the effusions, and in removing some of the other effects of chronic inflammation, such as thickening, hardening, and opacity of the parts. It should be given in small doses for a considerable length of time, until the gums are slightly affected. In many cases of depressed power it may be very advantageously conjoined with quinine and sarsaparilla. The most useful preparations are calomel or the green iodide of mercury, in half-grain doses, or, if a gradual and continuous effect be required, the perchloride in doses of one-sixteenth to one-twelfth of a grain.

Iodide of potassium is an alterative and absorbent of the greatest value, especially in the chronic inflammations of fibrous or osseous tissues, or of the glands, occurring in strumous constitutions. In these it may often be substituted with great advantage for mercury, and given in those cases in which that mineral would otherwise be administered. In many cases it is of essential service after a mercurial course ; some days should, however, be allowed to elapse after the mercury is discontinued before the iodide is given, otherwise salivation or even sloughing of the gums may result.

Sarsaparilla is a very useful remedy, and forms an admirable vehicle for the preparations of mercury or iodine. The fluid extract of red Jamaica sarsaparilla is the best ; and where the inflammation is associated with want of power, its value is certainly very great.

Cod-liver oil is of the very greatest value in the various strumous forms of chronic inflammation, or in those occurring in debilitated, emaciated, and cachectic subjects. It may be given in some vehicle, such as milk, orange-wine, or -juice, that covers its taste. In some cases it is advantageously conjoined with the iodide of potassium ; or, where there is much want of power, and strumous anæmia is present, with the preparations of iron. It is more particularly in children and young people that it is of service in removing the various effects of chronic inflammation.

Purgatives are often required in chronic inflammation. In robust subjects in whom the disease is active, salines may be employed ; to which, if there be a rheumatic tendency, colchicum may advantageously be added. In children a powder composed of one part of mercury and chalk, two of carbonate of soda, and four of rhubarb, will be found very serviceable.

The **sulphides of calcium and potassium**, especially the former, are recommended by Ringer as being of great service in chronic inflammations in scrofulous subjects, especially when they are accompanied by a tendency to suppuration. They hasten the process of suppuration, and the elimination by that means of the caseous inflammatory products. Ringer recommends for a child a mixture of much the same strength as the Harrogate waters—viz.,

one grain of the sulphide of calcium dissolved in half a pint of water, and of this one teaspoonful may be taken hourly. In adults, in whom this mode of administering medicine is seldom possible, a pill containing one quarter to one third of a grain of the sulphide may be taken three times a day.

Mineral waters, both taken internally or used as baths, enjoy a great reputation in the treatment of many chronic inflammatory affections. The choice of the water or the bath will, of course, depend upon the constitutional condition which forms the predisposing cause of the chronic inflammation.

Sea-air is beneficial in many forms of chronic inflammation, especially in those dependent on scrofula.

LOCAL TREATMENT OF CHRONIC INFLAMMATION.—In chronic inflammation, our local means of treatment are much more varied than in the acute form of the disease.

Local Blood-letting is often required with a view of directly unloading the vessels of the part; and this is accomplished by scarification, leeching, or cupping. Scarification is employed principally in chronic inflammation of the mucous membranes. Leeches may be very usefully employed in some forms of chronic inflammation, two or three being applied every second or third day.

Warmth and Moisture are not so serviceable in chronic as in acute inflammation, and care should be taken that they be not continued for so long a time as to make the parts sodden. An astringent or stimulant, such as liquor plumbi or spirits of wine, may often advantageously be added to the warm application.

Cold is seldom required in any but the advanced stages of chronic inflammation, in which there are debility and passive congestion of the vessels of the part. In order to remove this state of things, its application should not be continuous, but should be made twice or thrice a day, so as to occasion a sudden shock, and produce a constringent effect upon the enfeebled vessels. This is best done by pumping or pouring cold water from a height, or by douching, and should be followed by active friction.

Friction is often of great service in some of the forms of congestive inflammation, by the removal of the thickening, stiffening, and induration that result. Friction may be practised either with the naked hand, or with some embrocation of a stimulating or absorbent character.

Counter-Irritants are local applications which give rise to irritation of the skin of varying intensity according to their nature, the mildest forms causing merely a passing dilatation of the cutaneous vessels, as the application of a camphor liniment, and the most severe producing destruction of the skin and even of part of the subcutaneous tissue, as the moxa or an issue. The value of counter-irritation is recognised by all practical Surgeons, and counter-irritants are undoubtedly amongst the most effective local means that we possess for combating chronic inflammation; yet their mode of action is difficult to explain. The old theory that by exciting a local inflammation in the skin it was possible to draw the disease away from the deeper and more important parts is no longer tenable; the theory that by stimulation of the sensory nerves of the skin a dilatation of the superficial vessels is produced, accompanied by a corresponding contraction in the deeper parts, cannot be supported by scientific evidence; in fact, as Billroth has pointed out, it is probable that in many cases, especially in extremely sluggish chronic inflam-

mations, the good produced is probably rather by an increased afflux of blood to the affected part than by a diminution of the blood supply. Most counter-irritants are applied solely with the intention of causing a certain degree of hyperæmia or of inflammation in the part of the skin on which they are placed, while others exert, or are supposed to exert, at the same time a constitutional effect, being absorbed into the system from the cutaneous surface. Counter-irritants are classed according to the degree of local irritation they give rise to.

Rubefacients are those that cause merely dilatation of the vessels of the part to which they are applied. Hot fomentations and linseed-meal poultices, although not usually classed amongst rubefacients, certainly cause dilatation of the vessels. Friction with some stimulating embrocation produces hyperæmia, lasting for a longer time, and is useful in promoting the absorption of chronic inflammatory products, such as the thickening left round a joint after all inflammatory disturbance has subsided. They undoubtedly act by causing a general afflux of blood to the limb. Camphor-liniment or, if a stronger action is required, the compound camphor-liniment is that most frequently used. The ordinary mustard poultices or Rigollot's mustard-leaves produce the lowest possible degree of true inflammation, but if properly applied there is no blistering of the skin, although there may be slight œdema followed by desquamation of the cuticle. Mustard poultices are but little used in surgery. They are more commonly applied to the trunk for the relief of hyperæmia of internal organs. Oil of turpentine sprinkled over flannels wrung out of hot water is another common rubefacient.

Vesicants are those applications which cause a degree of inflammation sufficient to give rise to abundant exudation, which raises the corneous layer of the cuticle from the Malpighian layer beneath, thus forming a bleb or blister. Vesicants are extensively used in surgery to promote absorption of the products of chronic inflammation, and in some cases to check the process, as in the application of blisters in chronic synovitis or periostitis, or to the perineum in chronic prostatitis.

Although there are other means of producing vesication, practically the preparations of cantharides are the only blistering agents employed; of these the two most common are the Emplastrum Cantharidis, or common Fly-blister, and the Liquor Epispasticus. The former is applied to surfaces free from hair, the latter to the scalp or perinæum. In applying a blister, or the liquor epispasticus, it is essential that the part should be as free from grease as possible, and for this purpose it must be washed with soap and hot water, and afterwards, if it can be conveniently done, sponged over with a very dilute solution of ammonia, before the blister is put on. The blister should rise in from eight to twelve hours. When the bleb is fully formed, if it is not intended to prolong the action, it should be carefully pricked with a needle, but the cuticle should not be removed. It should then be covered with cotton wool and a bandage, or a little simple ointment on a piece of linen. If it be desired to prolong the counter-irritation, the cuticle may be removed, and the raw surface dressed with savine ointment, by which means it may be kept open as long as is wished.

A blister does not, as a rule, leave a scar; but it may do so, and it is well therefore not to apply it to the face or hands if it can be avoided. The extent of surface to which it is applied must not exceed a few square inches, for there

is some danger of the absorption of the cantharidine, and of consequent congestion of the kidneys, hæmaturia, and strangury. This will of course happen more readily if there be a raw surface beneath the plaster. Blisters must always be used with great caution in very old or feeble subjects, and in those suffering from Bright's disease, or any other serious visceral affection, as in such cases they occasionally cause sloughing.

Suppurants or Pyogenic counter-irritants are those agents which are of sufficient intensity to give rise to inflammation reaching the stage of suppuration. The most common of these are croton oil, issues, setons, and the actual cautery.

Issues are of especial service in chronic inflammation of the viscera, joints, and bones, before suppuration has taken place. They should be applied in

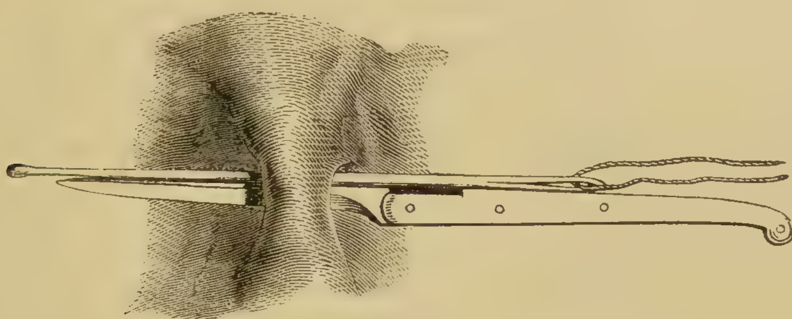


Fig. 86.—Introduction of a Seton.

the soft parts over the affected structures, and may be kept open for a very considerable length of time. They are best made in the following manner. A piece of adhesive plaster, about two inches square, having a hole of the size of a shilling cut in its middle, is fixed upon the part where the issue is to be made ; a piece of potassa fusa, about the size of half a cherry-stone, is then placed on the surface left uncovered by the circular central aperture, a square piece of plaster being laid over all. The patient experiences a burning pain for about two hours, when it ceases ; on removing the plasters, a black slough, corresponding in size to the central aperture, will be found. Water dressing should be applied for a few days, until it separates, and the raw surface then dressed with savine ointment, or stimulated by an issue-bead. Whenever it shows a tendency to heal, it may be kept open by an occasional application of the potassa fusa.

A **Seton** is more useful than an issue when counter-irritation is to be applied over very deep-seated parts. The seton may most conveniently be made in the following way (Fig. 86). A fold of skin about two inches or more in breadth is pinched up, and its base transfixed by a narrow-bladed bistoury. The blunt end of an eyed probe, threaded with one or more threads of thick well-waxed silk, is next pushed along the back of the blade from heel to point ; and the bistoury being withdrawn as the probe is carried onwards, the seton is left in the wound. Water dressing should then be applied.

The **Actual Cautery** is very successful in chronic inflammation of joints before destruction of the cartilages has set in, and it is especially useful when there is great pain with nocturnal startings. The relief obtained by its use is often immediate and permanent. In the application of the cautery it

is the object of the Surgeon to destroy the cuticle and the tips of the papillæ, but to leave the deeper structures of the skin uninjured, so that there shall be no contraction of the scar when the sore is healed.

For this purpose the cauterising iron should be of a dull red heat, and must be quickly drawn in lines crossing one another over the part. Paquelin's Thermo-Cautery is on the whole the most manageable and the cleanest form that can be used. The barbarous application known as a *moxa*, which consisted of cotton or pith soaked in saltpetre and allowed to burn upon the skin, is now no longer used in this country.

Two counter-irritants in addition to their local action produce constitutional effects when absorbed from the surface to which they are applied—viz., Iodine and Mercury.

Iodine is most commonly applied in the form of tincture; it should be painted on over the inflamed part twice a day till the skin becomes a little sore. This may be continued for weeks or months according to circumstances. It is no doubt a useful means of promoting the absorption of chronic inflammatory products, but the powers popularly ascribed to it are certainly far greater than it really possesses. The liniment is less frequently used, being a much stronger preparation, one application of which will often cause vesication. The ointment may be applied in some cases in which a somewhat stronger action than that of the tincture is desired, but it is not a cleanly application, and is not usually to be recommended.

Mercury is applied locally in many forms to promote the absorption of the products of chronic inflammation and in the treatment of the process. One of the most common modes of applying it to chronically inflamed joints is by the method known as Scott's dressing. This consists in spreading a thin layer of the compound mercurial ointment on a piece of lint of sufficient size to surround the joint. Over this strapping is evenly applied so as to exert a uniform pressure. In other cases the mercurial liniment or simple mercurial ointment may be of use. About ten years ago Marshall introduced a valuable preparation composed of the precipitated mercuric oxide dissolved in oleic acid. There is thus formed a definite oleate of mercury which is soluble in an excess of oleic acid. A solution made in this way containing five per cent. of the oxide is a clear liquid; when the oxide is increased to twenty per cent. it forms a solid unctuous substance, melting readily at the temperature of the body. As the oleate of mercury is slightly irritating to the skin, one grain of morphia may be added to each drachm. Marshall states that his experience of the use of this preparation in all forms of chronic inflammation has been most favourable. It is cleaner, more diffusible, more readily absorbed, and more efficacious than any other mercurial application. The very fact, however, that it is so readily absorbed should make us careful in using it in scrofulous subjects, who always stand mercury badly. Ten to thirty drops of the oleate, melted if necessary by a very gentle heat, and applied with a camel's hair pencil, is quite sufficient for one application.

Astringents directly applied to the inflamed parts are of extreme service in those forms of congestive or passive inflammation in which the circulation is sluggish and the capillaries loaded; they afford relief in these cases by inducing contraction of the vessels. In order to ensure their proper action, they must be employed of sufficient strength; for if too weak they irritate, and increase rather than relieve the congested condition. The nitrate of silver is the astrin-

gent that is commonly preferred; and this, applied either solid, or in solution containing from ten grains to one drachm of the salt in one ounce of distilled water, will produce a very marked beneficial influence in congestive inflammation of the mucous and cutaneous surfaces.

Pressure by means of well-applied bandages, elastic webbing, or strapping, is of essential service in supporting the feeble vessels in congestive inflammations. In many cases pressure may be advantageously conjoined with absorbents and rubefacients, as mercurial and camphor liniments, or the plaster of mercury and ammoniacum. This treatment, by removing congestion, and promoting the absorption of inflammatory effusion, is especially useful in chronic forms of inflammation accompanied by thickening of parts, as in the joints and testes.

CATARRHAL INFLAMMATION.

Catarrh or catarrhal inflammation is a form of the process of inflammation affecting mucous membranes and other epithelium-covered surfaces. All these are liable as other structures to traumatic inflammations of the ordinary type, in which as a consequence of the action of some irritant, the vessels dilate, the circulation is retarded, the white corpuscles migrate and the liquor sanguinis exudes, and the functional activity of the original cells is suspended or permanently abolished. The peculiarity of the catarrhal form, however, consists in the fact that although the vessels are dilated and exudation of blood-plasma and even the abundant escape of white corpuscles is taking place, yet the epithelium continues to exist and perform its function, and in most cases its cells multiply with unnatural rapidity. Catarrh may arise from the direct application of an irritant to the surface of the mucous membrane, as in the case of decomposing urine irritating the bladder or of gonorrhœal pus acting on the urethra. That in these cases the vessels of the corium and the submucous tissue should show signs of damage, by their giving exit to an abundant exudation and by the white corpuscles passing through their walls, while the epithelium is comparatively uninjured, showing signs rather of stimulation than of impaired function, at first seems rather inexplicable. It must not be forgotten, however, that epithelium is a structure which possesses in a high degree the power of resisting external injurious influences; and it is quite conceivable, therefore, that a cause which exerts no more than a stimulating action on the epithelium may, if it penetrate to the parts beneath, give rise to the phenomena of inflammation.

In other cases the cause of catarrh is not so clear, as when a patient is attacked by bronchitis, catarrhal nephritis, or cystitis, as the result of "catching cold." In these cases it is probable that the contraction of the cutaneous vessels causes hyperæmia of the internal organs, but hyperæmia alone is not sufficient to cause catarrh; probably the inflammation is due in part, at least in the case of the lung and kidney, to increased work thrown upon these organs in the elimination of those products of tissue-change which should be given off by the skin. Our knowledge is not, however, as yet sufficient to explain rationally the origin of all catarrhal inflammations.

The changes in the affected membrane depend on the degree of the process. In the mildest form there is some swelling due to exudation of serum. This partly distends the loose submucous tissue, and drains off by the lymphatics, and partly flows away from the surface of the membrane. At the same time

the cells of the epithelium multiply more quickly than natural, and many are loosened and come away with the discharge. In all mucous membranes there is an exaggerated formation of mucus during catarrh, and this increased secretion forms the most marked clinical feature of the milder form of the affection.

In more intense catarrhal inflammations, or **purulent catarrh**, the vessels of the corium of the mucous membrane are widely dilated, and the flow through them is retarded; liquid exudation is more copious, and the white corpuscles migrate abundantly. The leucocytes, which thus leave the vessels, wander amongst and through the epithelium-cells, the natural cohesion of which is somewhat loosened, and escape on the surface, forming with the liquid exudation a purulent discharge. The discharge in such a case, if examined microscopically, will be found to contain—numerous amœboid cells, presenting the usual appearance of white blood-corpuscles; ordinary pus-cells, round and granular with the tripartite nucleus; and epithelium-cells, some fully developed and corresponding in form to that natural to the affected membrane, some of rounded form young and imperfectly developed, and others containing a large transparent globule of mucus. A microscopic examination of a section of the membrane shows, that in spite of the abundant discharge of pus there is no raw surface; everywhere it is covered by epithelium. The wandering cells can be seen in the corium round the vessels and immediately beneath the epithelium. Some of the epithelium-cells will be found to contain within them several bodies identical with pus-corpuscles. These were supposed by Rindfleisch to show that the pus in purulent catarrh was formed by endogenous cell formation from the epithelium-cells. Later observations, however, have tended to prove that these apparent mother-cells are in reality dead or dying epithelium-cells, which have been penetrated by wandering leucocytes. Wandering leucocytes are also found penetrating between the individual epithelium-cells.

Although in purulent catarrhal inflammation there need be no ulceration, the above description shows how readily one process may be converted into the other. The adhesion of the epithelium-cells to each other, and to the corium, is always loosened in the more severe forms of catarrh; should the loosely adherent epithelial layer be accidentally removed by violence from without, or separated by exaggerated cell-migration beneath, a small ulcer will be the result.

Varieties of Catarrh.—Catarrh, like other forms of inflammation, may be *acute* or *chronic*. The chronic form is very frequently associated with passive hyperæmia of the part affected. It may also be *simple*, as in bronchitis, or *infective*, as in purulent ophthalmia or gonorrhœa. The thick muco-purulent secretion that forms on the surface of a mucous membrane during catarrh frequently serves as a nidus for the growth of microscopic organisms, and the fermentative changes these set up give rise to products which may prolong the irritation, and cause it to spread almost indefinitely.

Symptoms.—Redness of the affected surface, with slight swelling and an abundant secretion varying from a pure serous to a thick muco-purulent fluid, form the most marked clinical features of a catarrhal inflammation. The heat is usually moderate, and pain is not a marked symptom except in the more acute forms, as in purulent ophthalmia. The constitutional symptoms vary with the acuteness of the process and the part affected. As a rule, only the

most acute forms of catarrh give rise to any elevation of temperature. The absence of fever may possibly be accounted for by the fact that the exudation drains away from the surface and but little finds its way back into the blood-stream.

Parts which have suffered from chronic catarrh, or from repeated attacks of the acute form, usually become more or less pigmented, and the sub-mucous tissue is thickened and indurated. These signs are well seen in the mucous membrane of the bladder in cases of old stricture or stone.

The **treatment** of catarrhal inflammation presents little that requires special notice. In the more acute forms warmth and moisture, and above all removal of the discharge and prevention of its decomposition, form the most important means of treatment. Belladonna is often of use locally in diminishing pain and promoting contraction of the small arteries. In chronic catarrh, removal of the secretion and cleanliness with the use of astringents, such as nitrate of silver, acetate of lead, sulphate of copper or tannin, form the chief treatment. Any constitutional condition as scrofula or gout must be searched for and treated if found.

CHAPTER V.

SUPPURATION AND ABSCESS.

Suppuration, or the formation of pus, has already been described in the Chapter on Inflammation. It was there pointed out that the process consists essentially of a continuance and exaggeration of one of the factors of inflammation—the migration of the white corpuscles. The wandering cells accumulate outside the vessels, and possibly multiply by cell-division in their new situation, but this is extremely doubtful ; as the accumulation increases, the original tissues become pressed upon and absorbed, the new cells occupying their place ; finally, the central cells of the group degenerate from want of nutrition, their intercellular substance softens, and the liquid exudation from the surrounding part soaks in amongst them, and thus we get a creamy fluid, or pus.

If, as sometimes happens, we have the opportunity of examining microscopically such a small collection of pus in the subcutaneous tissue, the following appearances are observed, proceeding from the circumference to the centre of the affected area. The first sign of deviation from health is that some scattered leucocytes are seen in the spaces between the fibres of the connective tissues, and often evidently in the neighbourhood of a small vessel ; as the centre is approached, the number of these increases, gradually more and more completely obscuring the connective tissue and its corpuscles, till at last nothing is to be seen but closely-packed small round cells, between which the amount of intercellular substance is too small to be recognized ; in the centre of this group of cells may be a cavity from which the pus has escaped in preparing the section. The connective tissue, when it is last recognizable before being concealed by the infiltrating leucocytes, is seen to have its fibres swollen and vitreous in appearance, while its corpuscles are unchanged. They, evidently, are taking no part in the formation of the new cells, which are crowding amongst the fibres. If any blood-vessels are recognizable, it will be seen that, near the point at which everything is concealed by the leucocytes, they are filled with closely packed blood-corpuscles indicating the presence of a clot of blood. It is in this way that they are closed before, in common with the other tissues, they soften and break down in the presence of the invading leucocytes, and thus all hæmorrhage is prevented. In this area also, although it cannot be seen with the microscope, the plasma which has exuded from the vessels is coagulated, and with the migrated cells forms a firm substance, the so-called inflammatory lymph, which fills and plugs the spaces of the connective tissue, and thus forms a barrier round the collection of pus, and prevents its diffusing itself widely amongst the tissues around. It is not possible in a section made from a preparation removed from the body to observe the state of the vessels beyond the area of stasis or thrombosis ; but if it were possible to observe them in the living body, we should see, in a spreading abscess, all the conditions already described under Inflammation ; viz., from the centre towards

the circumference, stasis, oscillation, dilated vessels with retarded flow, adhesion of the corpuscles, and migration, and lastly, simple hyperæmia,—dilated vessels with increased rapidity of flow. Such a collection of pus as is above described, is a microscopic abscess ; an acute abscess holding half a pint of pus, differs from it in no respect except in size. The extension of the abscess takes place by progressive destruction of the tissues by the same process as that above described ; and the pus is formed by successive zones of the new

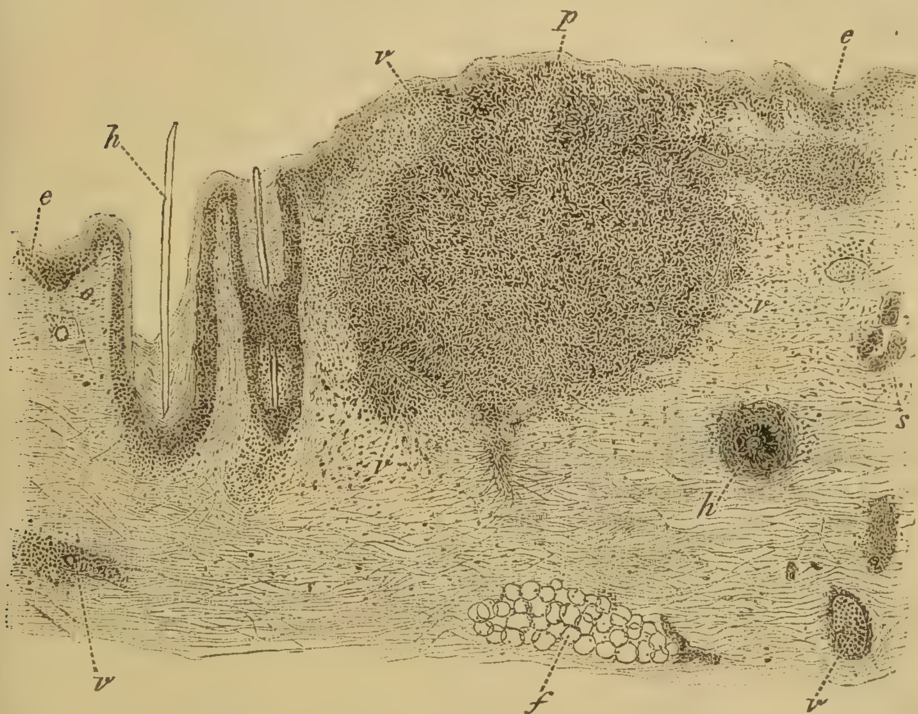


Fig. 87.—A Microscopic Abscess in the Skin. *e.* Epithelium; *h.* a Hair; *v. v.* Small Veins surrounded in some places by migrating leucocytes; *p.* the collection of pus; *s.* Sweat-gland; *h.* a small Artery; *f.* Fat. The Tissues round the collection of pus are dotted with leucocytes, becoming more closely packed as the centre of suppuration is approached.

cells degenerating, becoming separated from each other by fluid, and falling into the cavity of the abscess. The whole process is identical with ulceration, but instead of the discharge being given off superficially as in an ordinary ulcer, it accumulates in the abscess-cavity ; an abscess is in fact a cavity enclosed by an ulcer. The zone of tissue in which the process of spreading is taking place, was in former times spoken of as the "pyogenic membrane ;" but it is evident that there is nothing to which the term "membrane" could properly be applied ; the "pyogenic zone" would be a more correct term if any such is necessary. In this pyogenic zone the vessels are dilated, and the tissues softened, so that in opening an abscess blood may flow freely from the engorged vessels round the cavity ; but it must not be concluded from this that the abscess-cavity is surrounded by a zone of tissue in which new vessels have been formed. During the spreading stage of an abscess, it is destruction of vessels, not new formation, that is taking place ; the new formation occurs only during repair, after the pus has been let out.

The method in which pus is formed on mucous surfaces in purulent catarrh is described with that process.

That all the pus-cells are derived directly or indirectly from the white corpuscles of the blood, may now be regarded as an accepted fact in pathology. The proof of this fact is derived partly from the direct observation of the formation of pus, as it has already been described, and partly from the experiments of Cohnheim, Hoffmann, and Von Recklinghausen. These observers injected aniline blue or cinnabar into the blood-stream of the animal to be experimented on. It had before been shown that when solid matter in a state of extremely fine division is injected into the blood-stream, the white corpuscles pick up the particles in much the same way as an amœba takes its food; and the dark coloured particles of aniline blue or cinnabar are easily recognized in their substance. A frog having been prepared by the injection of the colouring matter, inflammation of sufficient intensity to cause suppuration was excited; and it was found that, whether it was in a vascular part or in a non-vascular, as the cornea, the pus-cells contained particles of the substance which had been injected.

Lastly, there is the negative observation, that in acute inflammations the original cells of the affected part undergo no change so long as they can be observed; that is to say, before they are concealed by the crowds of migrating leucocytes.

Characters of Pus.—Pus presents considerable variety in its general character, according to the cause that gives rise to its formation and the general constitutional state of the patient.

The pus from an acute abscess in a person otherwise healthy, is an opaque, creamy fluid, thick, smooth and slightly viscid, of a yellowish-white colour, with in some cases a greenish tinge: it has a faint odour and an alkaline reaction. Its specific gravity is from 1030 to 1033. It contains about 85 to 90 per cent. of water. Of the solid matter about two-thirds is albumen; of the remaining third, about one half is composed of fatty matter, including as a rule some cholesterine, and the rest consists chiefly of salts, with leucin, tyrosin, and a variety of other unimportant compounds. The salts are the same as those found in blood-serum, chloride of sodium being the most abundant. Pus presenting these characters is termed healthy or laudable pus.

Various other terms are applied to indicate appearances deviating from that of healthy pus; thus, when tinged with blood it is called *sanious;* when thin and watery, *ichorous;* when containing cheesy-looking flakes, *curdy*, and when diluted with mucus, *muco-pus*. Besides these, pus presents other varieties; thus, for instance, when it is formed in the brain it is of a greenish tint, and when in the neighbourhood of the alimentary canal it has a peculiar, fetid odour. Its chemical composition may likewise vary under different circumstances; thus, ordinary pus formed in the soft parts contains merely a trace of phosphate of lime, whereas that which is formed in connection with diseased bone is said to contain a large quantity of that salt.

Pus presents other peculiarities which in some cases are recognizable only by their effects on the system; thus the pus from specific sores possesses contagious properties, although to the naked eye it may not apparently differ from other forms of that fluid. In these cases, however, although we have not yet determined what it is that gives the pus its infective properties, one fact has been clearly shown, that all forms of infective pus contain organisms readily to be observed by the microscope. A specific

organism has not, however, been shown to exist for each disease which can be communicated by inoculation of pus—as, for instance, small pox, soft chancre, gonorrhœa and purulent ophthalmia; nor has it as yet been definitely proved that the organism is the actual cause of the infective properties of each kind of pus; still, all the observations of the present day would tend to suggest that such is possibly the case.

Pus is a liquid which readily decomposes when exposed to the air at the temperature of the body, or even if the causes of decomposition be introduced subcutaneously as by an aspirator-needle or trochar. Thus we occasionally see that a collection of pus which, when tapped for the first time, is free from decomposition, becomes offensive in a few days unless proper antiseptic precautions are taken during the operation. In some rare cases pus assumes a distinctly blue colour from the development in it of a special form of micrococcus.

Microscopic characters.—On examining pus under the microscope, it is found to consist of corpuscles floating in a clear fluid, the "liquor puris." In pus drawn from an acute abscess or from the surface of a healthy suppurating sore, two kinds of corpuscles are met with. Von Recklinghausen, Schultze, and others, showed that in such pus a large number of cells are to be found which resemble the white corpuscles of the blood in every respect.

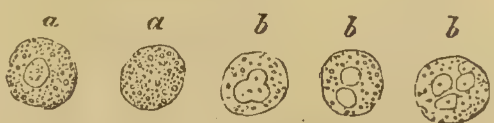


Fig. 88.—*a*. Healthy Pus-cells. *b*. Treated with Acetic Acid. Magnified 800 Diameters.

If examined when quite fresh on a warm plate, they manifest the characteristic amœboid movements. The nuclei of these living cells are single, or at most double, the protoplasm is faintly granular, and the nucleus can usually be recognised without the use of reagents. These living cells, however, as a rule form but a comparatively small proportion of the whole; the greater number present the appearances which have been held to be characteristic of the pus-cell ever since the microscope demonstrated its existence. They are essentially the same as the amœboid cells, but they are dead, and have, moreover, undergone degenerative changes. They are rounded in form, with a slightly irregular outline, they measure about $\frac{1}{2500}$ of an inch in diameter, and their protoplasm is coarsely granular, so that the nucleus is completely concealed. By treating them with dilute acetic acid the granules are to a great extent dissolved, the protoplasm becomes swollen and the nucleus comes clearly into view, and it is then found to be broken up into two or more, usually three, parts, most commonly without a nucleolus. This breaking up of the nucleus is a degenerative change and not a sign of active growth. In the protoplasm some fat-granules are usually to be seen which are not cleared up by the acetic acid. The number of these varies with the age of the pus; the less acute the formation of the pus the more abundant will be the fat granules, till in chronic abscesses we find them occupying the protoplasm to such an extent that it is no longer possible to clear it up with acetic acid. These granules are, however, readily dissolved in liquor potassæ. Finally, in very old collections of pus the cells break up completely, and the granules float free in the liquor puris, forming an emulsion having but little resemblance to pus, or in other cases they form curdy masses which in part float free in the fluid and in part form a layer on the wall of the abscess.

In the pus of acute abscesses, in addition to the corpuscles, granular débris of the tissues may in some cases be recognized.

During the last few years much attention has been paid to the presence of microscopic fungi in pus, the conditions under which they develope and the importance to be attached to them. This subject has been investigated by Burdon-Sanderson, Ogston, Cheyne, and others in this country, and by observers too numerous to mention in Germany and France; but it is chiefly to Weigert's method, perfected by Robert Koch of Berlin, that we owe the

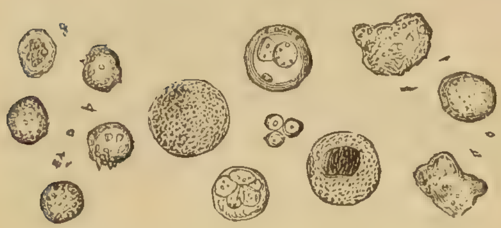


Fig. 89.—Pus-cells from Pyæmic Abscess.

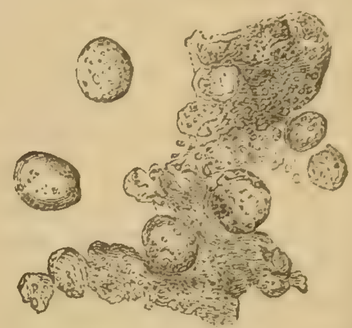


Fig. 90.—Pus-cells from Scrofulous Abscess.

ease and certainty with which the presence or absence of micro-organisms can now be determined. The results of these observations may be briefly summarised thus: in all acute abscesses minute round fungi (micrococci) are found in the pus when freshly drawn, but their origin, and the part they play in setting up the irritation to which the abscess is due, are still disputed points; after the abscess is opened, if rigid antiseptic precautions are adopted, the micro-organisms soon disappear from the discharges, but this result can be obtained only by very frequent dressings with carbolic gauze, or some other powerful antiseptic; under ordinary antiseptic precautions micrococci are present in the discharges as often as not. The pus containing micrococci shows no signs of decomposition. Pus exposed to the air, and more especially if it comes in contact with ordinary water, is soon found to contain, in addition to the micrococci, short rod-shaped organisms (bacteria). It then decomposes and gives off the ordinary offensive smell of putrefaction. In some cases of acute septicæmia the pus from the original source of infection has been found to contain long rod-shaped fungi (bacilli). In pyæmia, micrococci are always present both in the local source of infection and in the secondary abscesses. The pus from chronic abscesses is always free from organisms of any kind when freshly drawn. In the pus from specific inflammations, as gonorrhœa, small pox, purulent ophthalmia or infective periostitis, microscopic fungi are always found. In the majority of these processes they

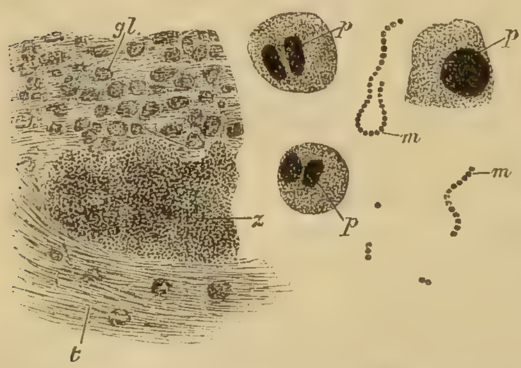


Fig. 91.—A colony of Micrococci in a lymphatic gland × 300. *gl.* Gland tissue; *z.* Micrococci; *t.* Pus from an Acute Abscess; *p.* Pus-cells; *m.* Micrococci in chains.

assume the form of micrococci, but their exact relation to the specific diseases in question is as yet very uncertain.

The examination of pus for microscopic organisms has been rendered so simple by the methods introduced by Koch, and the interest attaching to the subject at the present time is so great that it may be well here briefly to describe the process. The reagents required are, a solution of methyl-violet (one of the aniline dyes), of the strength of half a grain to one ounce of distilled water, carefully filtered, and some pure Canada balsam, which has been heated to drive off its volatile oil. The method of observation is as follows:—Spread the pus on a glass cover-slip in the thinnest possible layer, and dry it carefully over a spirit-lamp, taking care not to overheat it; dip a clean glass rod in the methyl-violet solution, and spread a thin film of the dye over the dried layer of pus; after from thirty to sixty seconds, wash the dye off carefully with a gentle stream of distilled water. A darkly stained film should remain behind, which must be again dried over the spirit-lamp; then while the cover-slip is still warm, put on it a drop of the Canada balsam, rendered fluid by heat, and place it quickly on a glass slide which is also slightly warmed; squeeze it gently down, and when cold it is ready for examination. The micrococci are distinguished from other granules by their definite round form and uniform size, and by their arrangement in groups or chains. They, moreover, take the dye readily, while fatty and albuminoid granules remain uncoloured. Blood or urine may be examined by the same process.*

Diagnosis.—The diagnosis of pus is usually easy, but some fluids resemble it so closely to the naked eye, that the microscope is necessary to establish their characters. From *healthy mucus* there is no difficulty in distinguishing pus; but when mucus has been thickened and rendered opaque by inflammation, and is mixed with exudation-cells, it is impossible, and can never be necessary, to distinguish it from pus. *Turbid serum*, containing broken-down and granular fibrine, frequently met with in serous sacs, and *softened fibrine*, as in clots and inflamed vessels, are distinguished from pus by the absence of pus-cells. *Atheroma* is recognised by the presence of cholesterine-scales and fat, and by the non-existence of the characteristic pus-corpuscle. When pus is diffused in *milk*, as in some forms of lacteal abscess, the corpuscles of this fluid will be seen to be smaller and clearer, with a more defined outline than those of pus. The largest fat-globules in milk are only half the size of a pus-cell, and the smallest one-fifth.

Circumstances influencing the Tendency to Suppuration.—It has already been pointed out in the Chapter on Inflammation, that suppuration is merely a certain degree of that process; and that the degree of inflammation in any case depends on the damage done to the living tissues by the irritant which is the cause of the disturbance. In order that suppuration may take place, it is necessary that a degree of damage shall be done to the walls of the small vessels which shall lead to abnormal adhesion of the corpuscles, retardation of the blood-stream, with migration of leucocytes and exudation of blood-plasma. If the damage be short of this point, mere hyperæmia will result without corpuscular exudation; if it pass beyond, stasis terminating in thrombosis will be produced, and the process of migration being arrested, suppuration is no

* For further information on the subject of Micro-organisms in the fluids and tissues of the body in disease, the student is referred to the Sydenham Society's Translation, by W. W. Cheyne, of Koch's work, "*Ueber Wundinfectionskrankheiten*," and Ogston's Paper in the *British Medical Journal*, vol. i., 1881, p. 369.

longer possible. In the next place, it is necessary that the irritation of the tissues should act persistently for some length of time, otherwise the exudation would not be of sufficient amount to form a collection of pus such as we can recognise clinically. For example, a clean cut inflicts a degree of injury on the parts actually touched by the knife sufficient to cause dilatation of the vessels, retarded flow, and migration; but if every other source of irritation be excluded, the whole process subsides before sufficient exudation has taken place to form an accumulation of migrating cells recognizable to the naked eye. If, however, a more persistent source of irritation be introduced into the wound, as pent-up serum causing tension, or decomposing matter, or even a mechanical irritant, as a foreign body, exudation of blood-plasma and migration of the corpuscles will continue, till the tissues on each side become infiltrated and finally replaced on the surface by the migrating corpuscles, and the space between becomes filled with the cells floating off from the surface in the liquid exudation, thus forming pus. Remove the source of irritation, and the formation of pus rapidly ceases. The direct effect of irritation in causing the formation of pus, may also be studied with great advantage in a healthy granulating sore—say, of the leg. If the patient be put to bed with the leg elevated, to avoid intra-vascular tension, and the raw surface rendered perfectly aseptic, and then covered by a non-irritating substance, and protected from mechanical violence and cold by an application which at the same time absorbs the discharge and prevents its putrefaction, every source of irritation being thus removed, we may succeed in absolutely preventing any formation of pus. The discharge, such as it is, will be composed solely of serous fluid, which necessarily leaks from the surface of the granulations, as they are uncovered by any impermeable epithelium. Having got the sore into this state, if some mild irritant be now applied, as for example, lint soaked in a concentrated solution of boracic acid, the discharge will become turbid, the superficial cells perishing and being cast off under the influence of the irritant, while at the same time migration takes place from the vessels beneath; if a stronger irritant be applied, as for example, carbolic acid water (1 in 20), the discharge will become thick pus, the granulations will swell and become soft from exaggerated exudation of blood-plasma and migration of leucocytes into their substance. Suppose now that a still stronger irritant be applied as a solution of carbolic acid in spirit (1 in 5), or chloride of zinc (40 grains to the ounce), the flow of pus will be checked, and the discharge will for a short time cease, or become merely serous, the dead layer formed by the caustic application serving to arrest any migrating cells that might be coming to the surface.

These two examples are sufficient to show that suppuration indicates always irritation of the living tissues of a certain degree of intensity, and persisting for a certain time.

It has before been pointed out that the effect produced by an irritant is proportional—firstly, to the strength of the irritant; and secondly, to the power of resistance of the tissues, or, in other words, to their state of health; and that for any tissue to be healthy, both the general and local conditions of nutrition must be healthy also (*vide* p. 159). The degree of inflammation necessary to cause suppuration, will therefore be more readily induced when any of the general or local conditions of healthy nutrition are interfered with. Paget examined the fluid that accumulated in the blebs in thirty patients to whom blisters had been applied for various affections. In those who were

suffering from purely local diseases, the constitution being otherwise healthy, the fluid was clear, sometimes coagulable, and comparatively free from corpuscles ; in cachectic or phthisical patients, it was turbid and crowded with wandering leucocytes ; and every intermediate variety was met with, according to the condition of the system. In scrofulous constitutions, the inflammation that is excited by a trivial injury, as the sprain of a joint for instance, is very apt to run on to suppuration. So, again, in certain cachectic states of the system, slight wounds suppurate or fester as it is termed.

The irritants which give rise to suppuration are innumerable ; but it is needless to repeat them here, as they have already been described under the Causes of Inflammation (*vide*, p. 159). From a purely surgical point of view, the most important are decomposition of the discharges, tension, and friction of diseased surfaces upon each other. That the "admission of air" acts as a cause of suppuration, is an observation of great antiquity. It was impossible for Surgeons not to be struck by the fact that a subcutaneous injury, such as a simple fracture or dislocation, heals rapidly without suppuration, while exactly the same injury complicated by a wound in the skin, is almost equally certain, unless special means are taken to prevent it, to be followed by profuse and prolonged suppuration. That the constituent of the air which does the mischief is its dust, and that the active part of the dust is in all probability the living organisms, which form a large part of it, has already been pointed out (p. 165).

Tension is in most cases the irritant which maintains the process of suppuration in an abscess, and causes it steadily to increase in size till it bursts superficially. In some abscesses, the specific nature of the pus gives it chemical irritating properties, which apart from tension may cause it to increase in size ; but these cases are much less frequent. The persistence of suppuration which results from the irritation caused by the friction of diseased surfaces upon each other, will be seen hereafter, in treating of diseases of the joints, to be a condition of great importance.

These facts as to the causation of suppuration are not merely pathological details of no importance to the practical Surgeon. In every case in which we have to deal with persistent formation of pus, we should carefully consider every cause that can possibly be present, both constitutional and local, to account for the condition, as it is only by the removal of the cause that we can hope to relieve the effect.

The Duration of suppuration varies greatly. In wounds in which, in consequence of tension from pent-up exudation, decomposition of the discharges, want of rest, or the presence of a foreign body, union without suppuration is not obtained, the discharge becomes distinctly purulent in the course of about three days, although occasionally it may be delayed for a longer time. When once suppuration has been set up, it will continue as long as the cause persists, and as the patient becomes weakened by the prolonged discharge, slighter sources of irritation are sufficient to maintain the process. From mucous membranes, especially when they suffer from mechanical hyperæmia, purulent discharges may continue for years.

SYMPTOMS OF SUPPURATION.—These are local and constitutional.

The **Local Symptoms** differ as the suppuration occurs on a mucous surface, or in the interior of a tissue or organ.

When an inflamed *mucous surface* is about to suppurate, the membrane pre-

sents the ordinary characters of active inflammation, being hot, swollen, red, and often painful; to these a discharge is speedily superadded.

When suppuration is about to take place in *the substance of tissues or organs*, so as to give rise to an abscess in one of the forms to be presently described, the local symptoms of inflammation undergo certain modifications indicative of the supervention of this condition. When the formation of pus is acute, the pain becomes throbbing; the part swells and becomes tense, but after a time softens; and fluctuation may be detected in it. The skin becomes glazed, red, shiny, and œdematous. In the formation of a chronic abscess, suppuration occurs without any evident sign of local inflammation, the presence of the pus revealing itself by swelling and fluctuation only.

Constitutional Symptoms.—On the supervention of acute suppuration the ordinary symptoms of inflammation are often interrupted by the occurrence of chills, alternation of heat and cold, or, if the formation of pus be extensive, by severe and long-continued rigors. If the pus be enclosed in a cavity, forming an abscess, the temperature rises considerably above normal, reaching 103° F. or 104° F. The evening temperature is as a rule about one degree above that of the morning. This high temperature remains unchanged in a case of simple acute abscess till the pus is discharged either artificially or naturally. It then falls rapidly, and if the cavity be completely drained, soon reaches the normal degree. When the abscesses are merely a part of the general process of blood-poisoning, repeated rigors occur, and although opening the abscesses may relieve the patient, it seldom brings the temperature to a normal point. When suppuration occurs in a recent wound or compound fracture, the fever which precedes it is due in the majority of cases to absorption of septic matter from the raw surfaces; consequently, as granulations spring up and cover them and present an efficient barrier to the entrance of the products of decomposition into the circulation, the fever falls, and this usually occurs coincidently with the full establishment of a thick healthy purulent discharge.

The slow formation of pus such as occurs in the development of a chronic abscess is unaccompanied by fever. If pus be formed in sufficient quantity for its discharge to act as a severe drain on the constitution, other symptoms set in, dependent on the loss that is going on. The patient becomes weak, the nutrition is impaired, and *hectic* is established, or albuminoid degeneration of the liver, spleen and kidneys sets in.

Hectic does not come on unless there be a discharge of pus from the system. No hectic occurs so long as an abscess, however large, continues unopened; but it may supervene with great rapidity when once its contents are discharged. I have known large abscesses to exist unopened for several years, without any constitutional disturbance; but, as soon as they were opened, well-marked hectic set in, which speedily carried off the patient.

Hectic is essentially a fever of debility; emaciation and general loss of power invariably accompany it. The pulse, which is quick, small, and compressible, rises from ten to twenty beats above its normal standard: the tongue becomes red at the edges and tip; the cheeks are often flushed, and the eyes glistening, with dilated pupils; all these symptoms have a tendency to exacerbations after meals and towards evening. There is also increased action, either of the skin, bowels, or kidneys. Thus, profuse sweating, copious purging, and abundant deposits of lithates in the urine take place; these discharges often

alternate with one another, melting the patient away, as it were, and hence are termed *colliquative*. The debility gradually increasing, the patient rapidly wastes, and at last dies from sheer exhaustion, the conjoined result of fever, malnutrition, and wasting discharges.

The nature of hectic fever has of late given rise to considerable discussion. There can be no doubt that in a very large proportion of surgical cases at least, it is in reality chronic poisoning from the absorption of the chemical products of putrefaction. For this to occur it is not necessary that the pus should be foul and stinking; a much milder degree of fermentative change is sufficient. The more essential condition is that the pus shall be confined in a cavity from which the drainage is imperfect, so that it accumulates at a slight degree of pressure sufficient to cause absorption of the products of putrefaction from the granulating surface. This view of the nature of hectic is supported by the facts, that no hectic occurs till after the abscess is opened, that improvement of the drainage will in very many cases relieve all the symptoms, and that very large superficial ulcers may exist for years and discharge abundantly without inducing the signs of hectic. Moreover, some of the symptoms of hectic resemble those known to be caused by the absorption of the products of putrefaction, as the profound anæmia and the tendency to diarrhœa. But few cases of hectic remain in surgical practice, if all that probably depend on this cause are excluded. It is likely that any continued febrile disturbance, from whatever cause, would tend to assume the form usually described as hectic fever if its duration were sufficient and its course sufficiently slow and wanting in intensity.

Albuminoid, or amyloid degeneration is a most important and serious consequence of prolonged discharge of pus. It is a very common effect of old-standing joint- or bone-disease accompanied by suppuration, and when once established it exerts a most injurious influence on the progress of the case, and especially on all operations undertaken for the cure of the disease. In surgical practice it is most commonly met with in children, as diseases of bones and joints are more common with them; but similar conditions cause a similar result in the adult.

The pathology of the process belongs rather to Medicine than to Surgery, but it will not be out of place to give here those symptoms with which every Surgeon should be familiar.

The organs chiefly affected are the liver, spleen, kidneys, and the intestinal mucous membrane. The chief symptoms are gradually increasing anæmia and emaciation, not necessarily accompanied by any fever. The liver gradually but steadily increases in size till it may reach from the fifth rib to the right iliac fossa. Its surface is smooth, and its sharp, hard edge can often be felt through the thin abdominal walls almost like a piece of india-rubber. There is no jaundice or ascites. The spleen may be felt, but is seldom very large. When the kidneys become affected, the urine usually contains a small quantity of albumen and a few hyaline casts. As the villi of the intestines become implicated, the emaciation increases and attacks of diarrhœa are common. Towards the end of the case œdema of the ankles is a frequent symptom, arising from feebleness of the heart's action and the watery state of the blood. Death occurs from exhaustion or from some intercurrent disease.

There is only one treatment for the disease, and that is to remove the source of the suppuration; and if that is impossible, to adopt every means in our

power to diminish the quantity of pus discharged. Evidence is still wanting as to the curative effect of complete removal of the source of the pus, as by amputation of the limb in which the diseased joint or bone is situated. In one case recorded by Barwell in which amputation at the hip was successfully performed for disease of the joint in a child aged seven years, the general condition greatly improved after the operation, and the size of the liver decreased. A still more interesting case occurred under the care of my colleague, John Marshall, at University College. The patient was a boy aged about ten, who had long suffered from extensive disease of the hip. The signs of albuminoid disease were well marked, the liver reaching nearly to the umbilicus. Amputation at the hip-joint was performed, and the boy made a good recovery. Ten years after he returned to the hospital on account of a small abscess in the stump due to some necrosis of the bone near the acetabulum. At this time he was carefully examined, and no enlargement of the liver could be detected. When the disease is far advanced, however, such operations are out of the question, as the condition of the patient is such as to make it impossible for them to withstand the necessary shock and loss of blood.

VARIETIES OF ABSCESSES.

Suppuration may occur on the mucous or serous surfaces, or on the surfaces of ulcers or wounds, constituting *Purulent Exudation;* or pus may be collected in the interior of a tissue of an organ, forming an *Abscess.*

An **Abscess** signifies a collection of pus occurring in any of the tissues or organs of the body. Surgeons divide abscesses into various kinds, according to the symptoms attending them, their duration, and their cause. Thus they speak of Acute and Chronic, Hot and Cold, Lymphatic, Diffuse, Metastatic or Pyæmic, and Puerperal Abscesses.

Acute or Phlegmonous Abscess may be taken as the type of the disease. When it is about to form, the part which has been previously inflamed swells considerably, with a throbbing pulsatile pain; the skin becomes shining, glazed, and of a somewhat purplish red. If the abscess be very deeply seated, the superimposed tissues become brawny and œdematous, without perhaps, any other sign indicating the existence of pus. As the swelling approaches the surface, it softens at one part, where fluctuation becomes perceptible, and a bulging of the skin covering its summit takes place.

An abscess has a special tendency to approach a free surface, whether that be external or internal, skin or mucous membrane; the tissues between it and the surface towards which it is progressing being gradually broken down. That the abscess always extends most rapidly in the direction of least resistance, seems most probably to be due to the fact that dilatation of vessels and migration of cells will occur more easily on that side; the pressure of the accumulated pus tending to obstruct these processes on that side on which there is the greater resistance. This process is spoken of as "the pointing of the abscess." As the pus approaches the surface, the skin at first becomes more or less livid, tense and œdematous, indicating the interference with its circulation; as the summit of the abscess presses upwards, the overlying skin loses its tension and becomes relaxed; it then sloughs at the most central point, from which the cuticle has previously peeled off, and, the outward pressure of the pus speedily detaching the slough, the abscess

discharges itself. Though acute abscesses, if left to themselves, usually run this course and burst through the skin, the mucous or serous surfaces, or even into the interior of joints, yet some collections of pus, if very deeply seated, cannot find their way to the surface, but extend through the areolar planes of the limb in a lateral direction, burrowing and undermining the parts to a great extent : or, if situated in dense and unyielding structures, as in bone, are imprisoned within a case through which they may be unable to penetrate ; in other rare instances, the pus becomes absorbed, and the abscess disappears.

After an abscess has burst or has been evacuated, its walls contract and become corrugated, and the cavity is gradually closed by a process of repair identical with the healing of a wound by granulation (See Process of Repair, p. 277). In some cases, however, the cavity does not completely close, but contracts into a narrow canal forming a sinus or fistula (p. 252).

Diffuse Abscess is a term which has been incorrectly used to describe a rapid formation of pus in the areolar tissue, as the result of a spreading or infective inflammation. In a true abscess the pus is collected in a cavity and it results from a localised source of irritation; in diffuse suppuration the cause is either some readily diffusible and irritating chemical substance, as the products of decomposition, which spreads widely amongst the lymph-spaces of the areolar tissue, or some infective poison which multiplies and extends amongst the living tissues and is always associated with the presence of microscopic organisms. Hence the pus often spreads widely, and there may be extensive destruction of parts before it is discovered. A particular variety of this form of abscess is the *Puerperal*, occurring in women after parturition in various parts of the body, especially in the iliac fossa, in the areolar planes of the thigh or in the joints, and in the adipose tissue of the orbit, often destroying the globe of the eye. To these forms of the disease the **Metastatic Abscesses** are closely allied. They commonly occur as consequences of pyæmia, and will be more fully described with that disease. They may be very numerous, and are met with in the substance of organs as well as in the areolar tissue and joints. The last three species of abscess are varieties of the acute form.

Chronic Abscesses, or as they are sometimes called Cold Abscesses, are of very common occurrence, and arise under somewhat various conditions. Perhaps the most typical form is that which is so commonly met with in connection with diseased bones, especially the bodies of the vertebræ. In these cases the disease commences with chronic inflammation and possibly with death of a small portion of the bone, around which pus is slowly formed. From this starting point the pus, as it increases in quantity, slowly makes a cavity for itself, forcing its way in the direction of least resistance. The irritation caused by the presence of the pus, which in such cases is always free from organisms and chemically unirritating, is so slight that the surrounding areolar tissue, instead of becoming softened by infiltration with migrating leucocytes, as in an acute abscess, becomes consolidated partly by compression and partly by the growth of new fibrous tissue, till a wall of such density and distinctness is formed that it can be dissected out like that of a cyst (Fig. 91). Such an abscess slowly extends and may burrow to a considerable distance from its original starting point. The course it follows is determined first by the fascia beneath which it may be burrowing. As a general rule it does not

perforate a fascia, as this becomes thickened by the growth of new fibrous tissue rather than thinned by ulceration or pressure. Secondly, it burrows in the spaces along which the larger arteries run; thus, a psoas abscess after following the muscle beneath the fascia to the groin comes in relation with the profunda, and follows it amongst the adductor muscles, often sending out processes along the circumflex arteries and their branches reaching to the gluteal region. These abscesses do not readily point, and their duration is often very remarkable. I have seen large chronic abscesses in the iliac fossa and groin perfectly stationary for nearly two years. The fluid contained in such abscesses is thin, flaky and curdy, though in some cases the pus is healthy in appearance. Sometimes they contain masses of a soft yellowish substance, apparently formed of coagulated fibrin entangling the fatty remains of degenerated pus-cells, but more commonly the shreds and flakes are of small size. No microscopic organisms are found in the pus of a chronic abscess; and, however long it may remain unopened, it shows no tendency to putrefaction until air is admitted from without. When such an abscess has been opened the wall of the sac is found in most cases to be lined by a thin layer of adherent cheesy matter, in other cases it may be covered by a smooth layer of imperfect granulation-tissue almost resembling a mucous membrane in appearance. The cavity is often crossed by bands containing vessels of considerable size. Occasionally the fluid contents become gradually absorbed and the abscess undergoes spontaneous cure, its site being indicated by some dry cheesy matter enclosed in a dense mass of fibroid tissue.

Chronic abscesses of a somewhat similar character often form in connection with diseased joints, but the course of these is usually more rapid and the extent to which they burrow is not so great.

Another form of chronic abscess is that occasionally met with in the mamma; in which a few drops of curdy pus become surrounded by so dense a wall of fibroid tissue as to simulate a solid tumour. A similar form is found in the cancellous tissue of bone, but in this case the enclosing wall is formed of very dense compact osseous tissue. Such abscesses may exist for an indefinite period.

Chronic abscesses often form in connection with the lymphatic glands, in consequence of the gradual softening of caseous inflammatory products. Such abscesses are not uncommon in the neck, axilla, groin and iliac fossa.

In strumous children it is not uncommon to find a localised chronic inflammatory process set up in the subcutaneous tissue without any apparent cause. The inflammatory products undergo fatty degeneration and slowly soften. The skin becomes purple and congested, and finally gives way at one point, allowing the curdy fluid to escape, leaving a cavity beneath the undermined skin which is extremely difficult to cure.

Occasionally abscesses of considerable size form in the subcutaneous tissue without any evident cause, and with but slight precursory symptoms, or even without any at all. The patient, who has usually been cachectic, and has suffered some time from general debility, feels slight uneasiness in the groin, iliac fossa, or axilla, and finds unexpectedly a large fluctuating tumour in one of these situations; there is perhaps no pain in the part, and no discoloration of the skin, but the fluctuation is always very distinct. On opening such an abscess as this, there will usually be a copious discharge of thin unhealthy pus, which, when examined under the microscope, will be found to contain withered and fatty cells. In some cases, the contents appear to be a clear

semi-transparent or oily-looking matter. Such abscesses are often spoken of as *Lymphatic* or *Congestive.*

Many of the above forms of chronic abscess may arise from a deposit of tubercle, followed by softening of the growth and inflammation round it, but it is not always easy or even possible to determine certainly whether this has been the case or not.

The line between chronic and acute abscesses is not a sharp one. In some cases of joint-disease the process of suppuration may be acute at the commencement and gradually become chronic, the perforation of the capsule apparently relieving tension and reducing the irritation. On the other hand, it is by no means uncommon to see a chronic abscess assume an acute form, and rapidly increase and point after having been stationary for years.

Tympanitic or **Emphysematous Abscess,** which contains gas as well as pus, is occasionally met with in the neighbourhood of the alimentary canal, chiefly at the anterior and lateral parts of the abdominal walls, and about the sacrum. Sometimes there is a free communication with the intestine, in other cases it is not so evident. These collections are often resonant on percussion, and sometimes gurgling is very distinct in them.

Fig. 92.—Large Psoas Abscess extending down the Thigh and Leg.

Situation, Size, &c.—Abscesses are met with in all *regions* of the body, but more especially where the areolar tissue is abundant, and the lymphatic glands are numerous. They may occur at any *period of life*, from the earliest infancy to old age. I have opened a very large abscess in the axilla of a child about a fortnight old. Their *size* varies from that of a pin's point to a tumour containing a pint or more of pus. Some cases of chronic abscesses, when very large, are *multilocular*, the different cavities being connected by narrow channels of communication: in this way I have seen a large abscess extending from the lumbar vertebræ through the iliac fossa down the thigh, the ham, and the leg, until at last it was opened by the side of the tendo Achillis, having formed five or six collections of fluid, communicating with one another by contracted channels (Fig. 92).

Effects.—The *pressure-effects* of an abscess are often important. By pressure on the nerves of a part, it may give rise to very severe pain and spasm at a distance from its seat. The pains occasioned by the pressure of some forms of chronic abscess upon neighbouring nerves, have been mistaken for those of rheumatism or neuralgia. When blood-vessels come into relation with an abscess, they usually become coated by a thick layer of granulation-tissue,

which protects them from injury. In some cases, however, they are obliterated by the conjoined effects of the pressure and the inflammation, in which they, as well as the adjacent tissues, partake. In other cases, more particularly in strumous and cachectic individuals, the blood-vessels have been opened by ulceration and have burst into the sac of the abscess, occasioning sudden and dangerous or even fatal hæmorrhage. It is seldom, however, that a large artery or vein pours its contents into an abscess that has not been opened. These occurrences have taken place chiefly in the neck, in which situation both the carotid artery, as in a case described by Liston, and the internal jugular vein, have opened into the cavity of an abscess. The various mucous canals, especially the trachea and the urethra, may be injuriously compressed by neighbouring abscesses; so also bones may become necrosed, and joints inflamed and destroyed from the same cause.

Diagnosis.—The diagnosis of abscess, though usually easily made, at times requires close attention. The Surgeon believes that an acute abscess is about to form when, after rigors and some modification of the inflammatory fever, he finds the local signs characteristic of the formation of pus; more especially a throbbing pain in the part, with softening of any induration that may have existed, and œdema of the areolar tissue covering it. His suspicion is turned into certainty, and he knows that an abscess has formed, when, after the occurrence of these symptoms, fluctuation can be felt. Fluctuation is the sensation felt by the Surgeon on placing both hands, or one or more fingers of each hand as the case may be, with moderate firmness upon the part in which the fluid is situated, and then increasing the pressure with each hand alternately. On so doing, if fluid be present a wave will be felt to pass from under the hand which is pressing more strongly, raising that which is applied less firmly. In feeling for fluctuation the Surgeon should always place as large a surface of each hand as possible over the supposed fluid. The fingers should be curved so as to adapt themselves evenly to the part, and the pressure should be gentle and steady. If merely the tips of two fingers be poked into an inflamed part it gives pain to the patient, causing him involuntarily to wince and contract the muscles in the neighbourhood, thus obscuring all definite sensations of fluctuation. In large collections of fluid, as in ascites, one hand may be placed on one side and the opposite side struck a smart blow with the tip of the finger of the other hand, when a sharp impulse will be felt distinctly communicated through the fluid. This method of feeling fluctuation is, however, scarcely ever practicable in the case of an abscess.

Fluctuation may readily be confounded with the undulatory sensation communicated by some tissues from mere inflammatory infiltration into them. This, indeed, is a difference of degree rather than of kind: as pus would make its appearance in the course of a few hours, if the tumour were left to itself. Even without this, certain parts give very deceptive sensations, from their natural laxity, as is sometimes the case in the areolar tissue of the nates and thigh in persons of lymphatic temperament. A still more perfect sense of fluctuation is given by a muscle when the hands are applied transversely to its fibres; and, consequently, in all cases it is a good rule to feel for fluctuation with the hands applied first along and afterwards across the line of any muscle that may be situated beneath or over the suspected collection of fluid. Many soft solid growths give a sense of fluctuation almost as distinctly as fluid, deceiving even the most experienced. In the case of an encapsuled tumour the distinc-

tion can readily be made by pressing on its edge with the tip of one finger. If it is a chronic abscess or cyst, unless it be very tense, the finger goes through the swelling without anything being felt to move; in the case of a tumour the solid edge is felt to roll away. In some rare cases, even when fluid is present, fluctuation may be wanting, as the tension may be too great to allow of a wave being produced in the contents of the cavity. The occurrence of fluctuation alone, however, is not of itself sufficient to determine more than that a fluid exists in the part. The question necessarily arises, is this fluid pus? In the majority of instances, the history of the case, the character of the pain, the previous existence and the continuance of symptoms of inflammation, enable the Surgeon to answer in the affirmative. But if, as in chronic or cold abscesses, there be only obscure evidence of inflammation having existed, and if the swelling be of long standing, the fluctuation being perhaps deeply seated and indistinct, the safer plan will be for the Surgeon to introduce an exploring needle, and to see what the true nature of the fluid is; by this simple means many embarrassing mistakes in diagnosis may be avoided.

The tumours with which abscesses may more easily be confounded, are those *soft solid growths* in which there is a high degree of elasticity, giving rise to a species of undulation, as in some soft sarcomata. *Fluid tumours* of various kinds, such as cysts and enlarged bursæ, may also be confounded with abscesses. In these cases the previous symptoms, the situation, and the general appearance and feel of the tumour, will usually enable the Surgeon to effect a ready diagnosis; but should any doubt exist, the grooved exploring needle or a trochar may be introduced, when, if pus be present, a drop or two will escape. The "aspirator" is of especial service in cases in which it is desirable to withdraw some of the contained fluid for closer examination. The most common form of aspirator consists of an exhausting syringe from which lead two short nozzles fitted with stop-cocks. To one of these is fitted an india-rubber tube, at the end of which is a sharp hollow needle with a terminal opening. The needle should not have an eye some three-quarters of an inch or more from the point, as is frequently the case. In using the instrument, it should first be tested with a solution of carbolic acid (1 in 20). By this we disinfect and cleanse the needle, and prove that everything is in working order. Both stop-cocks being closed, the piston of the exhausting syringe is raised and retained in its position by giving the handle a quarter turn. The needle is then pushed in till its opening is buried beneath the skin, when the stop-cock leading to it is turned on. The vacuum then extends into the needle, and if it be gently and steadily pushed in the direction of the suspected abscess, the moment its point enters a cavity containing pus the fluid will pass up into the syringe. A piece of glass is interposed in the india-rubber tube, so that the nature of the fluid can be seen, even if the quantity be small. It is the use of the needle in this way, with the vacuum in it, that forms the essential feature of the aspirator as invented by Dieulafoy, and distinguishes it from the old suction-trochar. It avoids the danger of passing the hollow needle completely through the collection of pus before the suction is applied, and thus failing to detect the fluid. In chronic abscesses, even when a large needle is used, it often becomes choked immediately by the flakes of cheesy matter floating in the fluid, but this rarely happens before enough fluid has been obtained to indicate its nature.

Fig. 93 represents Coxeter's aspirator, which can be converted, if necessary, into a syphon. One stop-cock C, as represented in the drawing closes both tubes. The piston A being withdrawn, and a vacuum so produced, the cock C is turned so that it is parallel to the syringe, and the vacuum is thus put in connection with the needle D. While doing this, the small cock at E must be closed. If it be determined to use the apparatus as a syphon,

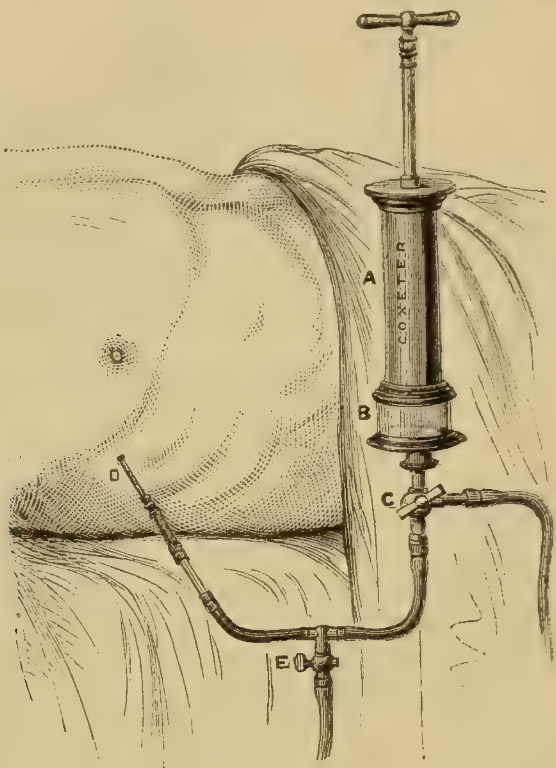


Fig. 93.—Aspirator, convertible into a Syphon.

A. Brass syringe. B. Glass at lower end. C. Stop cock, putting the syringe into connection either with the discharge pipe or the needle. D. Needle. E. Small cock, opening into a side tube, to be used as a syphon if required.

the cock E must be opened, and the handle of the piston forced down so as to fill the long tube passing downwards from E with the fluid already drawn from the cavity. The cock C now being turned off, the fluid will continue to flow.

The diagnosis of an abscess having pulsation communicated to it by a subjacent artery, from an *aneurism*, will be discussed when we come to speak of that disease.

Prognosis.—Abscesses vary greatly in danger, according to their nature, size, situation, and cause, and the constitution of the patient. The chronic form is usually attended by more risk than the acute, but this risk has been greatly diminished by the introduction of the antiseptic treatment. The puerperal and pyæmic are especially hazardous to life, being merely a part of a general infective process. The large size of some abscesses is an element of great risk, occasioning not only a very abundant discharge of pus, but likewise great constitutional disturbance when they are opened, unless they can be successfully drained and all decomposition of the discharges prevented. Abscesses that are situated in the neighbourhood of important organs, as about the neck of the bladder, or in the anterior mediastinum, are necessarily

much more hazardous from the peculiarity of their situation than those which are met with in less important regions. The cause of the abscess also influences the result: if it be a piece of dead bone that can be removed, the discharge will speedily cease if the fragment be taken away; but if it be so situated that it cannot be got rid of, it will, by acting as a continuous source of irritation, keep up a discharge that may eventually prove fatal. The constitution of the patient influences our prognosis. Such an amount of discharge as would inevitably prove fatal in a cachectic system, may influence a sound one but very little; so also, the wasting effect of an abscess is better borne about middle age than at either of the extreme periods of life.

TREATMENT.—The treatment of suppuration presents three points requiring attention. The first object should be to prevent the formation of matter; the next to take steps for its evacuation when formed; and the last to endeavour to close the cavity that results.

In order to *prevent the formation of matter*, it is necessary to get rid of any local irritant that may exist; thus a foreign body should be removed, or extravasated urine be let out of the areolar tissue. After this has been done, the preventive treatment must consist in the active employment of local antiphlogistic means, such as ice and cold evaporating lotions: the swelling from exudation-matter, which is especially the precursor of chronic abscess, must be got rid of by the continuous application of some discutient lotion. One composed of iodide of potassium ʒi., spirits of wine ℥i., water ℥vij., is extremely useful. In some cases absorption may advantageously be promoted by mercurial ointments or plasters. When once pus has formed, it is a question whether it can be absorbed again; in general, it certainly cannot, but in some cases it may undergo absorption; thus, in hypopyon, we occasionally observe that the pus deposited in the anterior chamber of the eye is removed. The more fluid parts of chronic abscesses occasionally become absorbed, leaving a cheesy residue, in which lime salts may afterwards be deposited forming a cretaceous mass.

When, notwithstanding the employment of appropriate means, it is evident that pus is about to form, the treatment should be completely changed, and, by the aid of warmth and poultices, an endeavour should be made to *hasten suppuration*. When this is fully established, the abscess having become "ripe," steps must be taken for the *evacuation of the matter*. The treatment of acute and of chronic abscesses differs in some respects. In discussing the **Treatment of Abscess**, we shall consider, in the first instance, its management by the methods ordinarily in use, and secondly, by the antiseptic plan.

In an **Acute Abscess**, the matter should be let out as soon as it is fully formed, especially in those varieties of the disease connected with a morbid state of the system, as in the metastatic and pyæmic forms. When this is done, the constitution at once experiences great relief, the fever and general irritation subsiding materially; the free incision not only letting out the pus, but removing tension. The rule of opening an acute abscess early is especially imperative when the pus is formed in the sheaths of the tendons and under fibrous expansions where there is much tension; also when it is situated deeply in the areolar planes of a limb, under the larger muscles, where it has a tendency to diffuse itself extensively. In those cases, likewise, in which pus is lodged in close proximity to a joint or under the periosteum, it must be let out early; so also, when it presses upon mucous canals or important organs, as on the urethra or trachea, or when it is dependent on the infiltration of an irritant

fluid into a part, as in urinary extravasation, it must be evacuated without delay. The pus should always be let out early, before the skin covering it is thinned, when the abscess is situated in the neck or in any other part where it is desirable that there should be as little scarring as possible.

In **Chronic Abscess**, the rule of surgery is not so explicit. Here the collection is often large, coming on without any very evident symptoms and giving rise to no material inconvenience; but, if it be opened, putrefaction of the pus, consequent upon the entry of air into the extensive cavity, will give rise to the most serious constitutional disturbance, setting up fever, or giving rise to septicæmia or pyæmia; and, should the patient escape this danger, the drain of an abundant suppuration may speedily waste him. Hence, it not uncommonly happens that a patient may carry a chronic abscess unopened, without any very serious disturbance, for many months or even years; but when it is once opened, he dies in a few days. When this happens, death occurs from direct poisoning by the chemical products of putrefaction, not by any infective process in which the poison multiplies in the blood. The effects of the putrid matter being proportional to the dose, if putrefaction cannot be prevented by antiseptic treatment, we must try to diminish the quantity of decomposable matter in the sac of the abscess. Free incisions and large drainage-tubes do much to diminish the risk attending the opening of a chronic abscess without antiseptic

Fig. 94.—Abscess Bistoury.

precautions. If the chronic abscess be so small that no danger is to be apprehended in opening it, or if it be situated in parts where it may give rise to dangerous pressure, the matter should be let out without delay.

There are three modes by which abscesses may be opened, each of which possesses advantages in particular cases;—these are *Incision*, *Tapping* with a trochar or aspirator, and making an aperture into the cyst with *Caustic*.

Incision is the only plan that should be practised in *acute abscesses*. For this purpose a lancet, an abscess-bistoury (Fig. 94), or a sickle-shaped knife, may be used. The incision should be made either at the point where fluctuation is most distinct, or at the most dependent part of the tumour, so as to prevent subsequent bagging of the matter. It should be made by holding the bistoury or lancet short, and introducing it perpendicularly into the softened part. If the depth to be reached be considerable, a bistoury should be used, the blade of which should be half turned round after its introduction, when the pus wells up by its side, the point being felt to move freely in the cavity of the abscess. The incision must then be continued for a moderate extent in the direction of the natural folds of the skin of the part, or in the course of the vessels. The pus should be let out freely, so as to allow the walls of the abscess to collapse, but it should not be forced out by squeezing the sac.

As soon as the pus ceases to flow, a drainage-tube may be inserted, or when this is not used a small piece of lint soaked in carbolic oil, or simple oil if that be not at hand, must be inserted between the lips of the wound to prevent their adhering immediately to each other.

It may happen, after the escape of the pus, that the cavity of the abscess is

filled with blood by the rupture of some small vessel situated in its walls; this, however, is of little moment, the hæmorrhage speedily ceasing on the application of pressure by a bandage, or of cold. Provided the incision have to be carried only through the integumental structures and fascia, in order to afford an outlet for the pus, there can be but little danger of hæmorrhage from an accidental wound of any blood-vessel of importance; and, should bleeding occur, it will probably be of a venous character, and may be arrested by pressure and position. It is wiser, however, for a Surgeon to make it a rule never to open even a superficial abscess without having the necessary means at hand for the arrest of arterial hæmorrhage. When the abscess is more deeply seated than this, lying under the superficial muscles, which it will then be necessary to penetrate, more serious consequences may ensue, and the incautious use of the knife may lead to the most perilous results. These are more particularly apt to occur in deeply-seated sub-periosteal abscesses of the thigh; and I have more than once known such profuse arterial hæmorrhage follow incisions made for the purpose of evacuating pus deeply lodged in the limb in these cases, as to necessitate the ligature of the femoral artery. In order to avoid this danger, Hilton advised that abscesses so situated should be opened in the following way. An incision is made through the integuments and fascia so as to expose the muscle under which the pus lies; a director is then pushed through the substance of the muscle into the cavity of the abscess, and along the groove of this a slender pair of dressing-forceps is pushed: when it reaches the abscess the blades are opened up, the muscular fibres separated, and free exit given to the pus. The opening thus made must be maintained by the insertion of a drainage-tube, or the patient's condition will be but little improved, for the muscular fibres come together again as soon as the dressing-forceps are removed, and proper drainage being thus rendered impossible, the pus will soon re-accumulate, and, air having been admitted, will probably decompose and give rise to septic poisoning.

After the opening has been made, the cavity left eventually fills up either by the coalescence of its sides, or by granulating from below; if it fill again with pus, a fresh incision, termed a "counter-opening," must be made in the most dependent part. Nothing is more dangerous than pent-up matter in imperfectly opened abscesses. It speedily decomposes and becomes offensive, gives rise to local irritation and inflammation, and predisposes to the occurrence of erysipelas and pyæmia. In order to prevent these evil consequences, recourse must be had to free openings in dependent situations, and the use of the drainage-tube.

In the treatment of *chronic and cold abscesses*, the time and mode of opening varies with the variety of abscess with which we have to deal. When the collection was of large size and very slow formation, as in a psoas abscess from disease of the spine, it was formerly the custom to wait until an opening was rendered necessary by the tendency to implication of the skin, or by injurious pressure being exercised on important parts. The pus was then let out by the valvular aperture recommended by Abernethy, the object being to prevent the entry of air into the interior of the abscess, so as to lessen the chance of putrefaction of any pus that was left. The valvular opening was made by drawing the skin covering the abscess well to one side, then passing the bistoury directly into the sac, and allowing as much of the pus to escape as will flow out by the collapse of the walls of the abscess; before the matter had

quite ceased to flow, and consequently before any air could have entered the sac, the skin was allowed to recover its natural position, so that the aperture in it and in the wall of the abscess might no longer directly communicate. A piece of plaster, or of lint soaked in collodion, was placed upon the external wound, which often healed under this covering in the course of a short time. When the cyst of the abscess had again filled somewhat, this process was repeated; so that, less and less pus being allowed to accumulate in it before each succeeding evacuation, it might gradually contract and close. This mode of treatment is seldom practised in the present day; but, instead of making the valvular opening in this way, a chronic abscess may sometimes be advantageously opened by **Tapping with a Trochar and Cannula** of moderate size, the instrument being introduced obliquely between the skin and the abscess, and then made to dip down into the sac. After the withdrawal of the cannula, the aperture may be closed as in the former case.

Since the invention of the **Aspirator** by Dieulafoy, that instrument has to

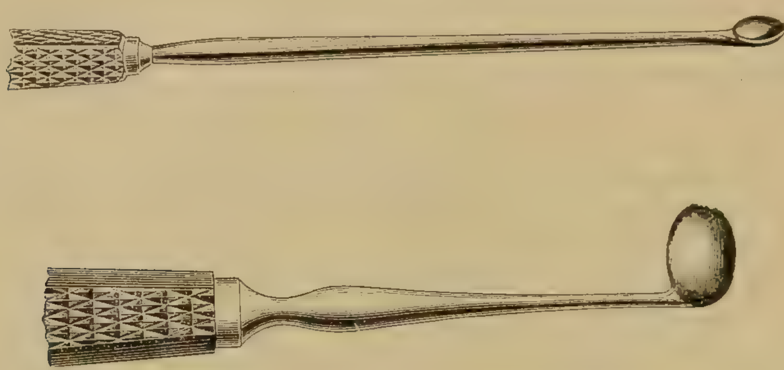


Fig. 95.—Two forms of Volkmann's "Sharp Spoon."

a great extent taken the place of the trochar and cannula, as by its use the entrance of air is effectually prevented. There is, however, one disadvantage in this plan of opening abscesses; that, if the discharge be curdy or shreddy, it is very apt to block up the cannula or needle, and thus to interfere with the proper evacuation of the matter. It is very seldom, however, that any of these modes of treatment cure a chronic abscess. The time comes at last in almost all cases when it must be opened. By carefully carrying out the antiseptic treatment, to be presently described, this may be done without causing the slightest constitutional disturbance; but if from any cause that be not possible, the septic fever following the admission of air may be kept down so as to be scarcely dangerous by making very free incisions and inserting large drainage-tubes, so that the quantity of decomposable matter shall be reduced to a minimum.

In opening a large chronic abscess, the wound should first be made only just large enough to admit the forefinger, which should immediately be thrust in before the pus escapes, so that the interior of the cavity can be examined before it collapses. In this way the size and shape of the abscess, its probable origin, and the presence or absence of loose fragments of bone or other foreign bodies are most easily determined. In doing this, however, care should be taken not to tear through the bands which are often felt crossing the cavity, as these sometimes contain vessels of considerable size. If much shreddy or

cheesy matter can be felt in the cavity, it must be carefully removed by means of a small scoop or sharp spoon.

In the treatment of chronic abscess in connection with joints, very free incisions, laying the cavity completely open from one end to the other, at its most dependent part, will be found to give the best results.

In small chronic abscesses, such as those arising in connection with caseating glands, or in scrofulous subcutaneous abscesses, which frequently occur in situations in which it is desirable to avoid a scar, the best mode of treatment is to make a puncture, through which a small "sharp spoon" (Fig. 95) can be introduced, by means of which all the half-softened cheesy matter can be removed. After the cavity has been thoroughly scraped out, a small drainage-tube should be inserted. These operations as a rule succeed much better if performed with antiseptic precautions.

Potassa Fusa, though its application be painful, may be advantageously used for opening those chronic subcutaneous abscesses, the skin covering which is much undermined, congested, and discoloured. In these cases I commonly employ it with great advantage.

In some forms of chronic abscess it will be found that those processes which

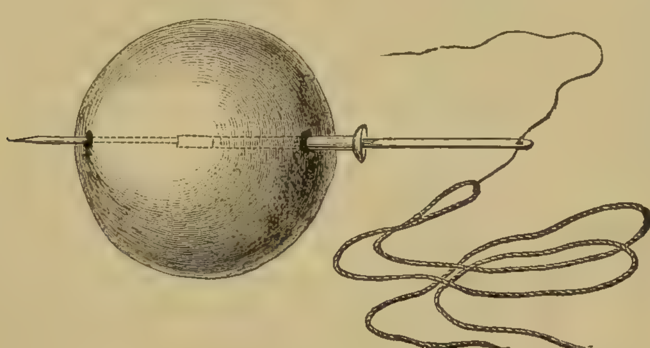


Fig. 96.—Introduction of Seton into Abscess through Cannula.

are necessary for the contraction and closure of the cavity, after its contents have been evacuated, do not readily take place; and it becomes necessary to have recourse to measures, which, by exciting inflammation in the wall, bring about changes which are followed by healing. With this view, a **Seton** of two or three threads may very usefully be passed across the cyst by means of a nævus-needle, or by a long straight needle pushed up through a cannula used for tapping (Fig. 96). It should be left in for a few days, by which time healthy inflammation will be set up. In other cases again, after the cyst has been tapped, the red wash or diluted tincture of iodine should be **injected** and left in. These methods of exciting inflammation are especially useful when the wall is thin, and of a very chronic character. When the wall is very thick and dense, as sometimes happens in abscesses of very old standing situated in the neck, an elliptical piece of the superficial portion should be dissected out, and the cavity lightly dressed, and allowed to fill by granulation. This plan of treatment is often very successful; and I have by it cured abscesses in the neck of seven or eight years' standing, which have resisted every other plan employed.

The **Drainage-tube** was introduced into modern surgical practice by Chassaignac. It is of the greatest value in keeping the cavities of abscesses, and,

indeed, the interior of wounds generally, free from those fluid accumulations which are apt to undergo decomposition, and thus become the source alike of local irritation and of constitutional infection.

In 1855, in the "Gazette des Hôpitaux," was published the following description of Chassaignac's method of employing surgical drainage:—"The principle of *Surgical Drainage* consists in establishing a continuous outward flow of the fluids, or, in other words, in bringing about a sort of drying-up of purulent collections. It is necessary to employ tubes of vulcanized caoutchouc of different diameters, the medium size being that of a crow's quill, pierced at intervals with small holes like those of the eye of a catheter. These tubes are placed across abscesses or purulent collections in such a way that the liquids penetrating through the holes in the sides of the tubes may easily flow along their whole length, and continuously drop from their ends or from that one which is more dependent. These tubes are introduced in the same way that a seton is . . . . the end of the tube is split in two, and each piece is fixed to the skin by a strip of plaster." To this description nothing need be added. No improvement has been made on the method devised by Chassaignac more than a quarter of a century ago.*

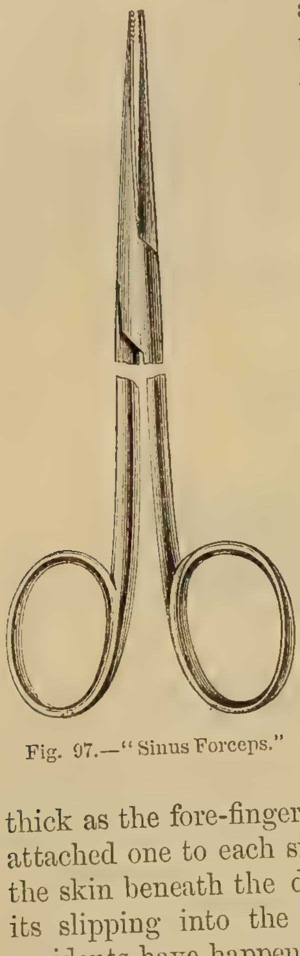


Fig. 97.—"Sinus Forceps."

Drainage-tubes are especially useful in the treatment of chronic abscesses. The tubes made of the red India-rubber are the most durable. They must correspond in size to the capacity of the cavity they are intended to drain; not so much because a small tube could not carry off all the fluid that escapes, but because the larger tubes are less likely to get accidentally choked, and the larger the cavity, the more serious would be the consequences of such an accident. For a large psoas-abscess the tube first used should be at least as thick as the fore-finger. A couple of threads about 2 inches in length, must be attached one to each side of the superficial end of the tube. These lie upon the skin beneath the dressing when the tube has been inserted, and prevent its slipping into the cavity. This precaution is very important, as many accidents have happened from its not being taken. A few years ago, a patient threatened an action for damages against the authorities of a hospital, because through the neglect of this detail on the part of a dresser, the tube had slipped into the cavity of an abscess, and had been lost and forgotten; by which accident the cure was considerably delayed. If the tubes are intended to be used as part of the antiseptic treatment, they must be kept in a solution of carbolic acid in water (1 in 20) for at least twenty-four hours before being used.

A drainage-tube is used in the following way. The abscess having been punctured and the pus allowed to escape, the depth of the cavity is measured

* But the surgical drainage of abscesses was employed three centuries ago in the case of Philip the Second, King of Spain. Dr. Curran (*British Medical Journal*, vol. i., 1881) gives the following most interesting quotation. The words describing this contrivance occur in a very rare book, entitled *De Felici Excessu Philippi Austriaci, Hispanorum Regis* . . . Scripsit Hispanice Cerverra Turrianus, Capell Reg., etc. They run as follows: "Deinceps ciendo puri quo Mane et Vespere Scutellæ duæ replebantur, ut testatur Garcias de Onante, *Chirurgicâ fistulâ opus erat, quæ exadmodum locis remotis saniem educeret*."

with a probe, or with a pair of small "sinus-forceps" (Fig. 97), which serve to introduce the tube. The depth having been ascertained, a piece of tube of the necessary length is cut off. It is then seized in the sinus-forceps, and pushed in till the open mouth with the threads attached is exactly level with the skin. If the tube passes in obliquely beneath the skin, its mouth must be bevelled so as to correspond accurately to the surface. If a long piece of tube be allowed to hang out, its end is folded over under the dressing, and thus the lumen is completely obstructed. Another very convenient way of introducing these tubes is, by fixing them on the end of a forked probe (Figs. 98 and 99), by which the tube is carried into the abscess and left there on the withdrawal of the probe.

Fig. 98. Forked Probe for introducing Drainage-tube.

Fig. 99. Drainage-tube and Forked Probe.

In some large abscesses it will be found convenient to pass in two tubes at different points. This is much better than passing a single tube through the cavity, as it allows the middle part to heal, and diminishes the chance of a troublesome suppurating track being left. A drainage-tube had better not be removed for three days, otherwise there may be some trouble in putting it in again; but by the third day, it has usually made a track for itself, into which it can readily be passed when it has been taken out for cleaning. If the case does well, as the abscess gradually closes from the bottom, the tube becomes pushed out; when this commences to take place, it must be gradually shortened to accommodate it to the diminished size of the cavity. A tube of smaller diameter may also be used with advantage as the discharge diminishes. In some cases the drainage-tubes have appeared to me to act in another way than by merely removing the purulent secretion; viz., by irritating the wall of the abscess just as a seton would, and thus setting up increased activity, and materially augmenting the discharge. On their withdrawal, however, this stimulation has been found to be beneficial, causing a speedier closure of the cavity.

The antiseptic treatment may be very successfully applied to the treatment of abscesses. By its means all the advantages of a free opening, giving ready exit to the discharges, can be obtained without the serious consequences which often follow the modes of treatment which have just been described, especially in the case of large chronic abscesses. The practice is founded upon the following principles :—1. The formation of pus, whether on the surface of a granulating sore or in the cavity of an abscess, is due to some abnormal irritation of the tissues.—2. In the vast majority of acute abscesses, the primary cause is of a temporary character, its exact nature often being uncertain; in other cases a distinct cause may be readily found, as an injury in an unhealthy subject, or the presence of an irritating foreign body.—3. The primary cause of the formation of an abscess being removed or having disappeared, the irritation set up by the tension of the parts in consequence of the accumulation of fluid is sufficient to cause the continuance of the process of suppuration, and the pointing of the abscess.—4. If this source of irritation be removed and no fresh irritant takes its place, and if no other irritant of a persistent character, such as the presence of a foreign body, have co-existed

with it, all suppuration will cease as soon as tension is relieved by letting out the pus, the only subsequent discharge being of a serous nature, coming from the surface of the granulations lining the cavity of the abscess. If this discharge be pent-up in the cavity, tension will be again produced, and, acting as an irritant, will cause fresh suppuration ; but if the discharge be allowed to drain away it will rapidly diminish, and the sac of the abscess will be obliterated by the ordinary processes of contraction and cicatrization. If dead bone exist at the bottom of the cavity, the reparative process, involving absorption or expulsion of the dead bone, will be very slow, the serous discharge often continuing for months without change, unless allowed to decompose, when it will rapidly become purulent and considerably increased in quantity.—5. In the ordinary method of opening an abscess, although the irritation due to tension is removed, a fresh irritant is admitted in the shape of the decomposition of the discharges, which in the mildest cases will seriously delay the closing of the cavity of the abscess, while in many, such as large psoas or lumbar abscesses, it may lead to such an amount of constitutional disturbance as to be rapidly fatal.—6. The cause of decomposition is not the admission of the gases of the air, but the presence of organic germs which are constantly floating in the atmosphere, and whose activity is readily destroyed by the direct action upon them of any powerful chemical antiseptic, many of which are volatile ; but experiments have shown that but little reliance can be placed upon their vapours mixed with air in such proportions as are practically attainable. Lister, therefore, in his method of treatment aims at the following objects :—1st. By freely opening the abscess, completely to evacuate its contents, and to provide a ready exit for the subsequent discharge, thus completely removing tension and preventing its return : 2nd, the entire exclusion from the opening into the abscess of air unmixed with a strong spray of carbolic acid or some other antiseptic ; the spray must be so fine that it shall be practically impossible for any solid particle floating in the air to escape contact with a drop of the antiseptic solution ; and 3rd, the absorption by some porous material, impregnated with a powerful antiseptic, of all discharges as soon as they escape from the wound—in short, the prevention of decomposition in the sac of the abscess, or in the discharges lying about the opening.

The most convenient antiseptic for these purposes is carbolic acid. The apparatus and materials required for opening and dressing an abscess antiseptically are—1st. A quart or more of a solution of carbolic acid in water (1 in 20). 2nd. Some thin cotton or linen rag free from holes ; called "*the guard.*" 3rd. Some thick green oiled-silk, coated with copal varnish, and covered with a thin layer of a mixture of dextrine and starch ; so that when dipped in the carbolic lotion, it may become uniformly wetted. This is called the "*protective.*" 4th. The *carbolic gauze.* 5th. Some thin mackintosh cloth or "*hat-lining.*" 6th. Some bandages made of the carbolic gauze, and some elastic webbing from 1 to 2 inches in width. The instruments required are—1st, the Spray-producer. If nothing else be available, a Richardson's ether-spray-apparatus filled with a solution of carbolic acid in water (1 in 40), may be used, but the steam-sprays are much more convenient and certain. The vessel for the carbolic acid must be filled with the 1 in 20 solution, which when mixed with the steam, is reduced to about 1 in 30. 2nd. A basin or deep flat dish filled with carbolic lotion, 1 in 40, in which all instruments are to be

placed. 3rd. A piece of drainage-tube suited to the case and fitted with threads. It must have been soaked in the 1 in 20 solution for twenty-four hours. 4th. The ordinary instruments for opening an abscess, and a pair of sinus-forceps for inserting the drainage-tube.

The opening of an abscess according to the Listerian method is done as follows. The skin all round for at least 9 inches when possible, must first be well washed with the carbolic lotion (1 in 40). It is often a good plan to wrap the part in a towel soaked in the carbolic lotion for an hour or two before the abscess is opened, especially when the patient's skin is very dirty. The steam spray is then turned on. Care must be taken to see that it is really blowing carbolic acid lotion and not water alone, as it would then merely sweep the dust of the air into the wound and encourage putrefaction. The Surgeon having thoroughly bathed his hands in the lotion (1 in 40) then opens the abscess with the knife taken freshly out of the same solution. As soon as the pus ceases to flow, the drainage-tube is inserted as before described. If it is desirable not to use the spray more than is absolutely necessary in order to avoid wetting the bed, the incision may be covered by the guard—that is to say, the piece of rag before mentioned—dipped in the carbolic lotion; and the pus may be allowed to flow out from under this, the spray being stopped for the time. As soon as the pus ceases to flow, the spray may be turned on again and the guard removed. The dressing is applied thus; a small piece of the "protective" dipped in the carbolic lotion is first applied to the wound, with a hole cut through it corresponding to the mouth of the drainage-tube. The object of this is to protect the tissues from the direct contact of the carbolic acid, which, as a powerful irritant, would arrest or at least delay healing, and cause more or less profuse suppuration. If the tube exactly fills the opening made, the protective is not necessary. Over this is placed a double layer of gauze, dipped in the carbolic lotion and squeezed as dry as possible. This has been found to give an additional safety, as the carbolic gauze often picks up pieces of dirt which are not disinfected by it in its dry state. Over the wet gauze are applied several dry layers, either smooth or crumpled up according to the form of the part. The quantity of this must be proportional to the amount of discharge that is expected to flow from the cavity. It must be arranged so as to fill up any natural hollows or irregularities of the part, so that the bandages may lie smoothly and evenly over it. The superficial dressing is then applied. This is composed of eight layers of carbolic gauze, between the two most superficial of which is placed a piece of thin mackintosh cloth, or as it is called in the trade "hat-lining." The object of this is to diffuse the discharge evenly throughout the whole dressing, and to prevent its soaking through at once opposite the opening into the abscess. If no "hat-lining" is available, of course any other water-proof material will act equally well. The dressing, which must extend at least 6 or 8 inches on each side of the opening, and furthest in that direction in which the discharge is expected to drain, is secured in its position by a bandage made of the antiseptic gauze, great care being taken to secure the edges. Lastly, elastic webbing from 1 inch to 2 inches in width according to circumstances, must be applied in such a way as to keep the edges of the dressing constantly in contact with the skin, in spite of any movement on the part of the patient. In the case of a dressing on a limb, a single turn secured by a pin at the upper and lower end of the gauze is all that is required. In other

situations the Surgeon must exercise his ingenuity in applying it in such a manner as to fasten the edges of the dressing securely on the part. It must, of course, not be applied so tightly in any case as to interfere with the circulation. The introduction of the few turns of elastic webbing in the application of the dressing has done more than any other late improvement to ensure the success of the treatment.

The gauze dressing thus applied acts in two ways:—1st, mechanically, by filtering any air which may pass through it, and thus excluding dust; and 2nd, chemically, by slowly yielding up to the decomposable fluids which soak into it a sufficient quantity of carbolic acid to prevent their putrefaction.

A carbolic gauze dressing must always be changed once in the first twenty-four hours after the opening of the abscess; or sometimes even before this if the discharge be very abundant. After this, it is customary not to change the dressing before the discharge shows at one edge; and this is found sufficient to exclude any signs of putrefaction, and practically to prevent the febrile disturbance and profuse suppuration which decomposing matter so frequently gives rise to. Experience has, however, shown that if the dressing be changed only when the discharge has soaked out from beneath it, the pus frequently becomes sour in smell and somewhat irritating, as indicated by a slight increase in the amount of pus discharged, and sometimes by reddening or excoriation of the skin. Observations made by Cheyne on Lister's cases, have shown that when this occurs, micrococci are always found in the discharges; rod-shaped organisms are found only when the dressing has failed entirely, and offensive putrefaction has set in. It seems, therefore, that the micrococci give rise to a fermentative process in the pus, the products of which are almost, though not quite, innocuous. Ogston has shown that by anticipating the soaking-out of the pus, by more frequent dressings, the development of micrococci can be prevented; and he is of opinion that the benefit derived from this is worth the extra trouble involved in dressing the abscess a few times more. It would seem that the micrococci are less easily destroyed by carbolic acid than the bacteria, and consequently as the dressing begins to lose its carbolic acid, partly by volatilization and partly by solution in the discharges, they make their appearance in the pus.

In changing the dressings, all the precautions observed at the opening of the abscess must be repeated.

Certain modifications of the above dressing require to be noticed. It is evidently impossible in many cases to make the dressing extend 6 or 8 inches beyond the opening of the abscess; in these cases the diminished extent of the dressing must be compensated for by increased thickness, twenty or more layers being applied in the place of the eight recommended above.

In hairy parts it is often difficult to disinfect the skin thoroughly before opening the abscess. In such cases, a thicker layer of wet gauze must be applied, or the skin may be anointed with a solution of carbolic acid in olive-oil (1 in 10) or in glycerine (1 in 8).

It must not be supposed that in the absence of all the materials and apparatus above mentioned, it is impossible to carry out the antiseptic principle of treatment; that is to say, to prevent absolutely all decomposition of the discharges.

The instrument most frequently wanting is the spray-apparatus; and fortunately this is the one which can most readily be spared. The spray

cannot at the present time be looked upon as more than an elegant mode of applying the carbolic lotion, its elegance consisting in its washing the air as well as the wound. In its absence, irrigation by means of a sponge squeezed over the part, or of an Esmarch's irrigator allowed to run on it, combined with a judicious use of the guard, will very well supply its place during the opening of an abscess, and the insertion of the drainage-tube. At the subsequent dressings, irrigation may be carried on whenever the wound is exposed. A very small amount of dexterity, and the exercise of a little common sense, will enable the Surgeon to treat almost any abscess antiseptically without a spray, the only exception, perhaps, being some of those about the chest and abdomen, in which air is freely sucked in and out of the cavity by the movements of respiration. Still, a steam-spray-apparatus gives great additional security during the early part of the treatment of a large chronic abscess, and it is better to use it if it is obtainable.

In the absence of carbolic gauze, a neatly made pad of carded oakum of uniform thickness, forms an excellent antiseptic dressing. It must be covered by some water-proof material to prevent the discharge from soaking through it too quickly. Oakum is an antiseptic dressing of great potency, but it is very irritating if applied directly to a raw surface, and it blackens the skin wherever it touches it. Any raw surface must therefore be covered with the protective, and the skin around should be greased with carbolic oil (1 in 10).

Absorbent cotton-wool impregnated with iodoform (iodoform-wool) makes a most excellent antiseptic dressing for all the smaller chronic abscesses, especially those connected with diseased joints and bones; and in subcutaneous scrofulous abscesses, and in those dependent upon softening tubercle, it is supposed by some to exert a specific curative influence. The abscess must be laid freely open and scraped out with a sharp spoon to get rid of any remaining cheesy matter; a few grains of iodoform may be introduced into the sac, and then, if necessary, the drainage-tube is inserted. The iodoform-wool is then applied, to the thickness, when lightly compressed, of about one inch and a half, and extending some six inches on each side of the opening; over this is placed an ordinary roller bandage. If no drainage-tube has been inserted, the dressing may be left on, if all goes well, either till some discharge shows out from underneath it, or till the abscess may reasonably be supposed to be healed; often for a month or six weeks. If a tube has been inserted, it is better to dress it once a week, to shorten or remove the tube. Any pain, or more particularly an elevation of temperature, is an indication for removing the dressing. Absorbent wool impregnated with salicylic acid, or silk waste containing about ten per cent. of the acid with a little glycerine, as recommended by McGill, can be used in the same way. They are free from smell, and cheaper than iodoform-wool, but their antiseptic properties are somewhat inferior.

Two or three layers of lint soaked in carbolic oil (1 in 10), or carbolic acid and glycerine (1 in 8), make very efficient antiseptic dressings, but they must be changed at least twice on the first day, and once every day afterwards.

In the absence of carbolic acid, spirit and water is an excellent antiseptic lotion, but it is not adapted for a permanent application, as it so soon loses its alcohol.

In the absence of all antiseptics, decomposition may be reduced to a minimum by securing perfect drainage by free incisions and tubes, so as to

diminish the decomposable matter to the smallest possible quantity ; and by avoiding the use of water, both during the opening of the abscess and afterwards—dry cotton-wool or linen rag being employed to wipe away the blood and discharges, and dry pads of cotton-wool or simply a piece of oiled rag being applied as a dressing.

If it is desired to apply warmth and moisture after the opening of an abscess, it is best done by means of a few layers of boracic acid lint, dipped in a hot, concentrated solution of boracic acid, and applied like a fomentation, being covered with a piece of oiled silk and a sheet of cotton wool. As an antiseptic, however, this is somewhat uncertain ; but it is an efficient disinfectant in cases in which the discharge is already foul.

If decomposition has taken place, either from the want of antiseptic dressings or from the failure of the treatment, complete disinfection is extremely difficult, if the cavity be of any great size, such as that of a lumbar or psoas abscess. The abscess may be washed out by injection of some antiseptic solution, such as Condy's fluid, carbolic acid lotion (1 in 40), or boracic acid, and by this means the offensive smell of the discharge may be diminished ; but the suppuration is kept up, or even increased, by the repeated application of these irritating fluids, and, at the same time, if they are discontinued, the signs of putrefaction soon return. Callender pointed out that this is in many cases due to the irregularity of the cavity and the impossibility of making the antiseptic reach every part of it, and he therefore recommended that the fluid should be pumped in at some degree of pressure, so as completely to distend the sac. After this has been done, some antiseptic dressing may be applied. The injection must be done under an anæsthetic, so as completely to relax the parts round the abscess. This treatment has been followed by very good results. The solution Callender used was the 1 in 20 carbolic lotion diluted with half its bulk of hot water. Chloride of zinc, 40 grains to the ounce of water, has been employed for the same purpose ; but it is a dangerous remedy, and had better not be used. A very dilute solution of iodine has also been used with good results. In injecting an abscess-cavity, however, with any antiseptic solution, great care must be taken not to use too much force, or the sac may be ruptured and the fluid diffused in the areolar tissue, an accident which might be fatal, especially if the stronger antiseptics were being used. Another plan lately recommended, is to introduce iodoform into the cavity by means of a brush, or on the end of the drainage-tube. It must not be forgotten, however, that iodoform dissolves very slowly and adheres to the wall of the abscess, so that if some is introduced daily, it may accumulate until a quantity is present sufficient to give rise to symptoms of poisoning. A case of this kind occurred in University College Hospital, which nearly proved fatal before the cause of the strange symptoms from which the patient suffered was discovered and removed.

Constitutional Treatment.—With the view of preventing the occurrence of suppuration, the Surgeon must be careful to maintain the powers of the system, and not to reduce the patient too much, even if the inflammation be of an acute character at the outset. Suppuration is a condition of debility, and is especially predisposed to by any previously existing enfeebled state of the system, or by malnutrition. Another reason for the avoidance of the early employment of debilitating means is that, if suppuration once be established, the drain on the system may eventually be so considerable as to require all the

patient's powers to enable him to bear up against it. Hence they should be husbanded from the first. While the abscess is discharging, nourishing, tonic, and even stimulating treatment will be required in proportion to the amount of debility that is induced. Amongst the most useful medicinal agents are mineral and vegetable tonics, the mineral acids, and cod-liver oil in the more chronic stages. Attention to hygienic conditions, with change of air, and residence at the sea-side, are also valuable. When hectic comes on, the same general tonic plan must be adopted, while we have recourse to means adapted to meet the local symptoms. Thus, acids are required to check the sweating, astringents to arrest the diarrhœa, and as much mild nourishment as the patient will bear to support the strength.

HÆMORRHAGE INTO THE CAVITY OF AN ABSCESS is not of unfrequent occurrence. It may arise from three sources: 1. Oozing of blood from the vascular wall of the abscess; 2. Ulceration into a vein; 3. Ulceration or sloughing of the coats of a neighbouring artery.

The **bleeding** which occurs **from the abscess-wall** is the most frequent, and the least important. It sometimes takes place before the abscess is opened, the pus that escapes being then found to be sanious and mixed with small coagula. More commonly it occurs after the opening of the abscess, in consequence probably of the wall having lost the support of the contained pus, when the vessels in the soft walls give way and the cavity speedily fills with blood. In these cases the hæmorrhage may be arrested by laying the cavity of the abscess freely open and turning out the coagula, when the bleeding usually ceases as soon as the interior is exposed to the cold air. Should this fail, it may be necessary to stuff the cavity with lint, or, if possible, with some antiseptic material as iodoform- or salicylic-wool, and to apply pressure with a bandage. When the cavity is closing, the vascular granulations which form upon its walls may bleed very freely if any pressure be accidentally brought to bear on the veins leading from the part. In this case the bleeding ceases immediately the pressure is removed.

Hæmorrhage from **Ulceration extending into a neighbouring Vein**, is necessarily far more serious. It has usually happened from sloughy abscesses formed on the side of the neck or under the angle of the jaw, as a consequence of scarlatina in strumous and unhealthy individuals, opening up the internal jugular vein. But it may arise, independently of any specific inflammation, in cachectic patients. In these distressing cases, the only treatment that can be adopted is, to plug the cavity of the abscess with lint soaked in a solution of the perchloride of iron, and supported by bandage or plasters. In this way the fatal event may be for a time perhaps delayed; but it is inevitable ultimately, the blood bursting forth by the sides of the plugs as these become loosened, or as the sloughing opens up the vein more widely. The effect of the bleeding is greatly aggravated by the depressed state of the system, labouring under the conjoined influences of a large sloughy wound and a specific poison.

If the hæmorrhage arise from the **Ulceration of a large Artery**, the case necessarily becomes one of extreme urgency. I have known this condition to occur in the neck and in the thigh; in the neck from sloughy scarlatinal abscess implicating the carotid; in the thigh, from the extension of ulceration from abscesses and sinuses to the deep femoral. When this untoward complication of abscess occurs in the neck, the hæmorrhage is usually so

sudden and so profuse that the Surgeon has not time to tie the carotid before life is extinguished. A. J. Pepper has, however, recorded a case of severe hæmorrhage after scarlet fever, which was repeated several times, and finally successfully arrested by ligature of the common carotid. The patient was a man, aged 30, and made a good recovery. In the thigh the case is not so urgent. Warnings by repeated small hæmorrhages may have enabled the Surgeon to adopt means to restrain the bleeding; and, in the case to which I allude, that of a young man, the femoral artery was tied successfully. In these cases, it is worse than useless to trust to secondary means for the arrest of the bleeding. When practicable, the artery should be compressed, the cavity freely opened up, and the bleeding vessel sought for and tied. If it cannot be found, the main trunk must be ligatured; and, for obvious reasons, this is the only course that can be pursued in the upper part of the neck.

Sinus and Fistula.—After an abscess has been opened, its cavity may not fill up completely; but, contracting into a narrow suppurating track, it may form a canal without disposition to close, from which a small quantity of pus constantly exudes, thus constituting a **Sinus** or **Fistula**.

The difference between a sinus and a fistula is this—that a sinus is merely a suppurating track penetrating to a greater or less depth amongst the tissues, closed at its deep end, and opening on the surface of the body. A fistula is an abnormal communication between two of the cavities of the body, or between a cavity and the surface, or a track through which the secretion of some gland or hollow viscus takes an unnatural course. Thus we talk of a sinus leading down to dead bone, but of a recto-vesical fistula, an aërial fistula, a urinary fistula, &c.

The *Causes* of this non-closure of the cyst of an abscess may be referred to the following heads:—1. The presence of a foreign body, as a piece of dead bone at the bottom; 2. The passage of irritating secretions, as urine, fæces, saliva, &c., through the abscess; 3. The contraction of neighbouring muscles; as when the abscess is in the neighbourhood of the sphincter ani, and as occasionally happens in abscesses about the limbs; and 4. The presence of an insufficiently drained cavity at the bottom of the sinus.

The orifice of a sinus or fistula when situated in hard and condensed tissues is often very small, depressed, and perhaps covered by a scab. In soft tissues it is commonly large and widely open; when communicating with bones there are usually soft, florid granulations obstructing it.

Structure.—A sinus consists of a narrow channel, often long and winding, having an external orifice usually somewhat protuberant, and situated under or among loose florid granulations. The walls of this channel, which are always indurated, are lined by a layer of imperfectly-formed granulations, exuding ichorous pus. If the orifice be occluded, this pus will collect within the sinus, and, distending its walls, reconvert it into an abscess. In structure, therefore, a sinus may be said to be a long, narrow, chronic abscess, with a permanent external aperture.

The granulation-tissue of a sinus, like that of any other granulating sore, contracts in healing, and consequently a healed sinus leaves a deep dimple in the skin. This is the best evidence of thorough healing; a sinus may always be expected to break open again if it skins over superficially without dimpling.

A fistula may differ in no respect from a sinus when its length is considerable, as in many anal and urethral fistulæ, but when it forms merely a short

communicating channel between two cavities, as between the rectum and vagina, or between the surface and a cavity or duct, as in a tracheal or salivary fistula, the granulations may become completely covered by epithelium continuous with that on each side, and no cure is possible till this has been cut away or destroyed.

The **Treatment** of a sinus or fistula has reference to its cause in the first instance; for, until the foreign body or the insufficient drainage that keeps it open and maintains the discharge has been removed, it will be useless to attempt its closure. After the removal of the obstacle to healing, we may endeavour to procure obliteration of the sinus by one of three methods.

1. *Pressure*, by means of a roller and graduated compress, so as to cause adhesion of its opposite sides, is useful in those cases in which the sinus is recent, without much surrounding induration, and so situated, as upon the trunk, that pressure can easily be applied.

2. A more healthy condition may often be produced in the sinus by injecting it from time to time with "red-wash," or with tincture of iodine, by the introduction of iodoform in crystals by means of a catheter or by soluble bougies such as are used in the treatment of gonorrhœa; by passing a probe coated with nitrate of silver to the bottom; by passing the threads of a seton or a drainage-tube through it.

3. *Scraping away* the callous and imperfectly granulating sides of the sinus by means of a small sharp spoon (Fig. 95), or destroying them by means of a red-hot wire or the thermo-cautery, is a very efficacious means of setting up a new and healthier action in the part, and so bringing about a closure of the canal. The galvanic cautery will often be found most convenient, as the wire can be introduced cold and heated *in situ*, and the danger of wandering from the track of the sinus is thus avoided.

4. The last method consists in *laying open the sinus* from end to end, and then dressing the wound so that it may heal from the bottom; in this way neighbouring muscles, that have kept it open by their contractions, may also be set at rest. The division of the sinus should be made with a probe-pointed bistoury, introduced through the external opening either by the aid of a director or without such assistance. The operation should be done effectually, the sinus being followed as far as is prudent, and laid open as completely as possible. Some fistulæ, as the fistula in ano, require similar treatment, and may be successfully and almost painlessly opened up by the slow action of the *elastic ligature*. A thin cord of vulcanised india-rubber being drawn through and tied tightly, ulcerates in a few days through the soft parts covering the track of the fistula. This plan is useful in cases in which hæmorrhage is apprehended or the patient dreads the knife.

5. Fistulæ which are lined by a complete epithelial covering, as many vesico-vaginal, recto-vaginal, and recto-vesical, can be cured only by destroying this, either by cutting or scraping it away or by cauterisation. Many such fistulæ require plastic operations for their cure.

CHAPTER VI.

ULCERATION.

By **Ulceration** is meant a progressive destruction of the tissues, in which the solid parts seem to melt away into a liquid discharge without the separation of visible portions of dead tissue. The meaning of the term will be made more clear by a few examples. If a piece of skin be killed in any way, as by the application of some caustic, or by mechanical violence, there is at first no solution of continuity, the dead tissue is everywhere continuous with the living: but within a few hours the phenomena of inflammation manifest themselves in the surrounding living tissues, thus imperfectly marking out the limits of the part that is killed. By about the second or third day the line between the dead and living becomes more clearly defined, the cuticle at the margin of the living part becomes loose, and is raised by fluid beneath it, and at last comes away, exposing a narrow raw surface discharging pus; the living tissues which lie in immediate contact with the dead, then seem gradually to melt away into the purulent discharge till a complete solution of continuity is established, the dead part, or, as it is called, "the slough," being completely loosened and cast off. This process, by which a slough is separated from the parts beneath, takes place entirely at the expense of the living tissues; it is spoken of as ulceration, and the sore left is called a *simple ulcer.*

The effects produced by the inoculation of the poison of a soft chancre form another excellent example of ulceration. Within twenty-four hours of the inoculation a small inflamed spot appears, with redness, swelling and itching: by the third day the cuticle is raised by a drop of pus; when the thin epidermic covering is removed a small red sore is seen, from which pus exudes: this slowly extends day by day, the discharge being purulent, and at no time do any visible portions of dead tissue come away with it; round the sore the tissues show the ordinary signs of inflammation. Such a sore would be called a *specific ulcer*, the irritant which causes the inflammation and destruction of the tissues being a specific poison.

A third form of ulceration, differing essentially from the two preceding, is seen in the later stages of the growth of malignant tumours. Thus an epithelial cancer commences as a small hard growth, which infiltrates the surrounding tissues. By the pressure of the growth which forces its way into the interstices of the structures which it is invading, the original tissues become absorbed, and the cancer-tissue comes to occupy their place. When the growth reaches a certain size its central parts degenerate, soften and break down, and a loss of substance takes place. As the disease progresses more and more of the surrounding tissue becomes invaded and destroyed by the cancerous growth, which in its turn breaks down and melts away superficially. Thus the most extensive destruction may take place. This process is described as ulceration, although here there may be no true inflammation, and the resulting sore is called a *cancerous or malignant ulcer.*

All these forms of ulceration have one feature in common; the original tissues are first infiltrated and pressed upon by cells foreign to the part, which destroy them and occupy their place; then in their turn the new cells perish, and are thrown off superficially with a fluid discharge, and thus a progressive destruction of tissue takes place. In the first two examples the invading cells are the white blood corpuscles which have migrated from the vessels, and in the last they are the special cells of the cancerous growth.

In the present chapter we have to deal only with ulceration as it occurs as a part of the process of inflammation.

An ulcer passes through two stages, viz., 1. Extension; and 2. Repair. To the former of these only is the term "ulceration" applied.

Pathology.—The process of ulceration when dependent on inflammation hardly needs a detailed description, as it differs in no essential feature from that already described as taking place in the formation of an abscess, the only variation being that in the latter case the formation of pus and destruction of tissue take place in a closed space, while in the former it occurs upon a surface. The separation of a dead piece of tissue from the surrounding living parts is thus accomplished. The tissue immediately in contact with that which is dead must necessarily have suffered to some extent from the injury which has caused the mischief, and its vitality thus being lowered, the phenomena of inflammation are manifested in it with an intensity corresponding to the degree of damage, and consequently diminishing as we recede from the parts that have been actually killed. Where the living tissues touch the dead the condition of stasis will be reached, and those vessels which pass from the dead to the living tissue will become plugged with clots extending as far as the next branch in the living parts. Beyond the area of stasis we should find that of retarded flow, accumulation of white corpuscles, and migration; and, beyond this again, that of simple dilatation with increased rapidity of flow or fluxion. The width of the area in which these inflammatory phenomena take place varies greatly. It may be merely microscopic, as in the separation of a piece of dead tissue which has been prevented from decomposing by antiseptic treatment, or it may extend for half an inch or more. Occasionally these vascular conditions can be recognised clinically by the effect produced by the pressure of the finger; in the area of fluxion it is scarcely possible to remove the finger before the brilliant red colour has returned; in that of retarded flow a second or more may elapse before the pale mark made by the finger has regained its red colour, and the tint in this area is a more dusky red than in that of fluxion; sometimes small red dots may be noticed in the pale patch formed by the pressure of the finger, indicating points at which some red corpuscles have escaped from the distended vessels. Lastly, close to the dead tissue may be seen a dark-red line unaltered by pressure, indicating the area of stasis and thrombosis, in which also many red corpuscles have escaped from the damaged vessels. From the vessels in the stage of retarded flow abundant exudation of blood-plasma and migration of the corpuscles take place. The wandering cells move in great numbers into the passive layer of tissue touching the dead part, and by their pressure destroy such remains of vitality as may be left; the original tissue softens and disintegrates, its place becomes occupied by closely-packed crowds of leucocytes; the leucocytes in contact with the irritating dead tissue in their turn degenerate, and becoming granular and losing their adhesion, are separated

from each other by the serous exudation from the neighbouring vessels, and thus pus is formed and the process of separation is completed. When this has taken place a surface is left covered superficially by a uniform layer of closely packed cells derived from the white corpuscles which have migrated from the vessels. Such a surface is a simple ulcer. The dead tissue which acted as a foreign body being removed, if no further source of irritation be present, the surrounding tissues recover from their impaired vitality, the inflammation subsides, migration ceases, and the process of **repair** commences. This process will be described in the next chapter with repair in general.

Ulceration, as it occurs from the inoculation of a specific poison, as in the example of the soft chancre before given, differs in no respect from that just described, except that at no time is there a visible piece of dead tissue cast off, and that the irritant which causes the process is developed persistently in the discharges, and, unless it be in some way destroyed, may continue to maintain the destructive process almost indefinitely. It is evident that if the irritating virus developed in the sore is of sufficient intensity, it may cause death of the tissues before the process of absorption of the original structures and substitution of a mass of leucocytes for them, has had time to be completed. It is under these circumstances that ulceration merges into spreading gangrene, the tissues no longer appearing to melt away in the liquid discharges, but remaining as a soft, partially disintegrated slough on the surface of the sore.

The process of formation of an ulcer in skin which has long suffered from chronic inflammation has been well described by Billroth. "Let us suppose," he says, "that we have a chronic inflammation of the skin of the leg, say on the anterior surface of its lower third. The skin is traversed by dilated vessels, hence it is redder than normal; it is swollen, partly from serous, partly from plastic infiltration: and it is sensitive to pressure. Wandering cells are infiltrated, especially in the superficial parts of the cutis: this renders the papillæ longer and more succulent; the development of the cells of the rete Malpighii also becomes more plentiful, and its superficial layers do not pass into the normal horny state; the connective tissue of the papillary layer is softer, and becomes partly gelatinous. Now, slight friction at any point suffices to remove the soft, thin, horny layer of the epidermis. This exposes the cell-layer of the rete Malpighii; new irritation is set up, and the result is a suppurating surface, whose upper layer consists of wandering cells, the lower of greatly degenerated and enlarged cutaneous papillæ. If at this stage the part were kept at perfect rest, and protected from further irritation, the epidermis would be gradually regenerated, and the still superficial ulcer would cicatrize. But usually the slight superficial wound is too little noticed, it is exposed to new irritations of various kinds; there are suppuration and molecular destruction of the exposed inflamed tissue, then of the papillæ, and the result is a loss of substance which gradually grows deeper and wider: the ulcer is fully formed."

Causes.—*The conditions essential to ulceration* are :—1. An irritant acting on a limited portion of the living tissues with sufficient intensity to cause the stage of retarded flow in the vessels with abundant migration of the white corpuscles, culminating in stasis and death in the parts mostly directly acted on. 2. A persistent action of the irritant for a sufficient time.

We have before seen, in the Chapter on Inflammation and Suppuration, that the effect produced on a living tissue by an irritant depends partly on the

intensity of the irritant itself, and partly on the power of resistance of the tissues, or, in other words, their degree of vitality. Consequently, the causes of ulceration, like those of inflammation in general, are divided into **Predisposing**, or those which render the tissues liable to suffer severely from injurious influences by impairing their vitality; and **Exciting**, or, in other words, the injurious influences themselves.

Predisposing Cause.—Everything that acts as a predisposing cause of inflammation is also a predisposing cause of ulceration (see page 159), and the following may be mentioned as amongst the most important. They are chiefly conditions that interfere in some way with the nutrition of a part. A feeble circulation, such as often exists in the lower limbs, in the alæ of the nose, and in newly formed or recently cicatrized tissues, predisposes to the formation of ulcers. As age advances, nutrition becomes impaired and the circulation less active, and slight causes suffice to lead to disintegration of the structure of a part. Hence we commonly see ulcers of the legs in elderly people, more particularly amongst the poorer classes, arising from slight irritation or pressure. Parts cut off from connection with a healthy nerve-centre ulcerate readily, as the nates in paraplegia.

Tissues that have been passively congested for a long time are apt to inflame under the influence of some trifling exciting cause, and to run rapidly into ulceration. This usually commences in the centre of the part, where the nutrition is lowest; here a small sore forms, which exudes thin unhealthy pus, and rapidly extends. So long as the sore is inflamed, it continues to spread, and reparation cannot take place. In some cases in which, from the above causes, the vitality has been greatly lowered, the exciting cause which is sufficient to give rise to ulceration may be so slight as to escape detection. This is especially marked in scrofula, scurvy, and syphilis. In some forms of scrofulous and syphilitic ulceration the process resembles in many respects that of malignant ulceration—the chronic, inflammatory products first forming a solid mass of very slow growth, almost like a tumour, which ultimately degenerates and softens in the centre, and is discharged superficially, leaving a raw surface, which slowly spreads by ulceration. Tubercular ulceration follows much the same course. These form a connecting link between simple inflammatory ulceration, and ulceration from malignant growths.

Exciting Causes.—The direct exciting causes of ulceration act chiefly on the skin and mucous membranes, and are very various in character :—

1. The most rapidly spreading forms of ulceration arise from specific infective poisons, as in phagedænic ulcers, hospital gangrene, soft chancre, the sore throat of scarlet fever, and in many syphilitic ulcerations. Most of these, at the same time, cause acute inflammation, extending to some distance beyond the area in which destruction of the tissues is visibly taking place. In such cases the action of the irritant may be so acute, and the destruction of the tissues so rapid, that the migratory cells may not have completely displaced the original structures before disintegration occurs. Microscopic shreds of the spoilt tissues are then to be found in the pus, which contains fewer genuine pus-cells and assumes often the form of a dirty brownish fluid, discoloured by the broken up red corpuscles from the disintegrating layer of tissue. When the irritant is more potent still, and penetrates into the surrounding parts, destroying them rapidly before any extensive migration has had time to take place, layers of disorganised tissue constituting "sloughs" are formed, which com-

pletely cover the surface, and the discharge may be merely serous fluid, scarcely turbid with cells. The whole process thus merges into gangrene. No sharp line can be drawn between spreading gangrenous inflammation and ulceration, and we call the intermediate conditions by such names as sloughing, gangrenous or phagedænic ulceration.

2. In parts which have long suffered from chronic inflammation, slight mechanical and chemical causes give rise to ulceration.

3. Ulceration sometimes commences in the crypts, or follicles, which open on mucous surfaces, as a consequence of catarrhal inflammation, with accumulation of secretion within their cavities. It leads to the formation of circular depressed ulcers.

4. In some general diseases, accompanied by the formation of vesicles or pustules on the cutaneous surface, ulcers may be left when they burst and discharge their contents, as in small-pox, pemphigus, syphilitic rupia, and occasionally in chicken-pox.

5. Any injurious influence, whether chemical or mechanical, which causes the death of a part, necessitates the occurrence of ulceration for the separation of the dead tissue, and the sore so left is an ulcer. Long-continued pressure is a common cause.

6. In some specific cases, as before stated, ulceration is preceded by the formation of a morbid growth, as a syphilitic gumma, tubercle, or a malignant tumour.

Situation.—Ulcers may be situated upon any part of the cutaneous surface as the result of loss of substance from wound or other injury. Syphilitic or strumous ulcers may appear on almost any part of either the skin or the mucous membranes, but they most frequently occur in particular situations as on the penis, lips, tongue, or rectum. Of all forms, however, perhaps the most common with which we have to deal, is the simple ulcer of the leg, so common in hospital out-patients' rooms, and amongst the poorer classes generally. The lower half of the leg is the usual seat of these simple ulcers, the skin of that part being much exposed to mechanical violence, and very prone to congestion, from position, from varicose veins, and from its great distance from the centre of circulation. In advanced life, moreover, degenerative changes in the arteries of the leg obstructing the flow of blood are very common. Ulcers that once form here are slow in healing, and very liable to recur, because the conditions that led to their formation may still exist; also there is often but a very thin layer of subcutaneous fat between the skin and the tibia, and, consequently, there is a great tendency for the under surface of the scar to adhere to the bone.

General Treatment of Ulceration.—In the **Local Treatment** of ulceration, the Surgeon must be guided by the special conditions presented by the ulcer, which will be described presently; but there are some points which demand attention in all cases. 1. Every source of irritation which could cause inflammation, or maintain it if present, must be carefully removed; for while inflammation is present no proper reparative action can go on. Thus, if the ulceration be due to the presence of a specific poison, as in the case of a soft chancre, this must be destroyed by antiseptic or caustic applications. In simple sores the surface must be preserved from friction, the part must be kept at rest, and the decomposition of the discharges must be prevented by proper applications. 2. The circulation must be maintained in a normal state, both

congestion and local anæmia being guarded against; as, without a normal supply and a sufficiently rapid change of blood, the growth of the reparative tissue cannot take place. Constriction by excessively tight dressings must therefore be avoided, and the part must be placed in such a position as will favour the return of blood from it. 3. Proper local applications adapted to the nature of the case must be employed, conjoined with uniform pressure, to support the dilated and weakened vessels of the part.

The **Constitutional Treatment** must be carefully attended to. Unless this be done, the best regulated local plan may be employed in vain. Attention to the digestive organs, and improvement of the constitution, if it be strumous or syphilitic, will do more in these cases than any other means can accomplish. The nutrition of the patient requires due care.

VARIOUS FORMS OF ULCER.

When ulcers occur in the skin, as the result of non-specific disease, they may be arranged under the following heads: the Healthy; the Weak; the Indolent; the Irritable; the Inflamed; the Phagedænic or Sloughing; the Varicose; and the Hæmorrhagic. Besides these varieties, each of which is marked by distinct characteristics, various other forms of ulceration depending on specific causes, as the Syphilitic, Scrofulous, Lupoid, Cancerous, &c., are met with; all of which will be treated of under their respective Chapters.

The varieties presented by ulcers are by no means dependent on local conditions merely, though these influence them greatly, but are in a great measure owing to constitutional causes. Indeed, the aspect of the ulcer, and the character of its granulations and of its discharge, are excellent indications of the state of health and of the general condition of the patient, as well as of the local disease.

In studying an ulcer clinically, we have to pay attention to the following points: 1. The surrounding skin. 2. The edges of the sore. 3. The surface of the sore. 4. The base of the sore. 5. The nature of the discharge; and 6. Pain and tenderness.

The Healthy Granulating Sore.—This may be considered the type of the disease. The *surrounding skin* is free from œdema; there is no change in it beyond slight hyperæmia close to the margin of the sore; *the edges* are regular in outline, shelve gradually down to the surface of the sore, and are marked by three zones of colour, an outer opaque white, a middle opalescent blue, and an inner dark red, as described in the Chapter on Repair. *The surface* is slightly depressed, and thickly studded with florid red granulations, firm in structure and uniform in size, each being about as large as half a mustard seed. *The base* of the sore is soft, and not adherent to deep-seated structures, as bones or fasciæ. The *discharge* will, under ordinary circumstances, be thick, creamy, laudable pus; but by carefully excluding every source of irritation, it may be made to assume a more or less serous character. There is absolutely no *Pain or Tenderness*. It is the object of our treatment in all cases to bring the other forms of ulcer into this condition.

Treatment.—In the management of the healthy granulating sore, the treatment should be as simple as possible; water-dressing and the pressure of a bandage usually enabling it to cicatrize. If simple water-dressing be employed, it must be changed three times a day, otherwise it will become offensive from putrefaction. Water-dressing is thus applied: a piece of lint

exactly the size of the sore is moistened with water, and put on the surface; over this must be placed a piece of oiled silk or thin gutta-percha tissue, overlapping the lint in all directions for about one-eighth of an inch. If the smallest corner of the lint projects beyond the oiled silk and comes in contact with the bandage, the dressing will speedily become dry and stick to the sore. In order that putrefaction of the discharges may be prevented, a point of very great importance where many wounded are crowded together, some antiseptic should be mixed with the water in which the lint is soaked. Perhaps the best of all antiseptics for this purpose is boracic acid, which should be used as a concentrated solution (p. 194). Carbolic acid solution (2 per cent.) has the great disadvantages of being irritating when first applied, and as the acid becomes volatilised by the heat of the body it soon becomes inefficient. Boracic acid lint, wetted with the lotion, may be applied to foul sores in the same way as ordinary wet dressing; when the sore becomes perfectly healthy and free from decomposition, its surface may be protected from the direct action of the antiseptic by covering it with the protective green oiled silk dipped in the lotion before being applied; over this the boracic acid lint may be placed either wet or dry to absorb the discharge. Another excellent application to a healthy ulcer is the boracic acid ointment spread on thin muslin, the whole being dipped in the lotion to make it apply itself smoothly before being put on the sore; over this may be placed a pad of salicylic silk or wool to catch the discharge, and the whole secured by a bandage. Boracic acid is a somewhat feeble antiseptic, and must be changed at least once a day. If, from any reason, it may be considered desirable to dress the sore less frequently, a more lasting dressing may thus be applied; wash the sore and the surrounding skin well with a solution of carbolic acid (1 in 40); put on a piece of the protective green oiled silk, completely covering the raw surface, and then apply the carbolic gauze dressing, as described in the treatment of abscess (p. 247). If economy be of consequence, one layer of gauze may be applied to keep the leg clean, over this may be placed a thick pad of carded oakum, and the whole covered by a common bandage. If the carbolic acid gauze irritate the skin, its place may be taken by eucalyptus gauze, or when cheapness is of less consequence, the part may be enveloped in a sheet of iodoform wool. By any of these modes of antiseptic treatment it is possible to get the ulcer in so clean a state, and so far to diminish its discharge that it shall not be necessary to change the dressing more than once a week. It will be observed that the object of these modes of dressing is to protect the sore from every possible source of irritation, including not only the acrid products of putrefaction, but also the antiseptic agent which is employed to prevent decomposition. Sometimes, however, as has already been stated, the healing process is retarded or arrested in consequence of the extent of the ulcer. In such cases, the transplantation of cuticle will, by affording centres of cicatrization, expedite the cure.

Whatever mode of treatment be adopted, if the ulcer be on the leg, rest in bed with elevation of the limb has more influence than any other condition in hastening the cure.

Transplantation of Cuticle.—It has long been known to Physiologists and to Surgeons, that portions of the tegumentary structures, when completely detached and transplanted to other parts of the surface of the body, occasionally retain their vitality, and grow where they have been inserted.

The experiments of John Hunter on the transplantation of teeth, and of the

cock's spur, the experiments of Abernethy on the same subject, the adherence and continued growth of a freshly separated portion of the nose or chin, the transplantation, by Buenger, of a piece of the skin of the thigh on to the face for the formation of a new nose, and the observation of Walther that the button of bone removed by a trephine, if re-inserted, will contract adhesions again—all prove the fact that freshly separated parts, if immediately re-applied to a raw surface, may contract adhesions to it. But it was reserved for Reverdin to show that cuticle, if transplanted, might be employed as an agent in the cicatrization of granulating surfaces. This observation was as interesting in its scientific aspect, as it was full of promise in its application to plastic surgery; and it has been found of great value in facilitating the healing of large ulcerated surfaces.

The growth of new epithelium over the surface of a sore takes place from the epithelial cells at its margin; and Reverdin showed that by planting small islets of freshly separated cuticle on the granulating surface, each can be made to form a centre for the development of new epithelium, which, spreading in all directions, coalesces with that growing from the surrounding skin, and thus covers the sore rapidly with a new cuticle. The covering of the surface with epithelium is, however, only a part of the process of cicatrization, the contraction of the granulation-tissue and its development into fibrous tissue forming an equally essential process. The hopes that were entertained at one time, that by the grafting of cuticle the contraction of the scar, which causes such extensive deformity in the case of large burns, could be prevented, have been but imperfectly realised. The process of grafting, in fact, in many cases amounts to little more than dressing the sore with cuticle, if such an expression may be allowed, the new epithelium cells growing over the surface long before the development of the fibrous tissue of the scar has made any appreciable progress. In such cases the cicatrix formed is very weak and apt to break down—much more readily than the scar produced by the natural process of healing. Moreover, even after successful grafting, much contraction frequently takes place as the granulation-tissue becomes completely developed into fibrous tissue. Still, although it has not answered the somewhat exaggerated expectations that it at first raised, transplantation of cuticle is of great use in promoting the healing of large sores; and probably, although it does not prevent the subsequent contraction, does in some cases lessen its amount.

The process of transplantation of cuticule is as follows. A piece of skin on some sound part of the body—the outside of the arm, for instance—about the size of an oat or a split pea, is pinched up with a pair of forceps, and snipped off with curved scissors. The whole thickness of the skin need not be separated, but merely the cuticle down to and including the papillary layer of the true skin, so as just to draw blood. The operation, when properly performed, is almost painless. The little patch of separated cuticle is now placed, with the raw side downwards, on the surface of the ulcer, covered and retained in position by a strip of isinglass plaster. It is left undisturbed for about four days, at the end of which time it will be found to be adherent; and it speedily becomes the centre of a new process, which spreads in a gradually widening circle, until it fuses itself into the epithelial growth proceeding from the circumference of the sore, or from other transplanted islets; and thus the surface is rapidly covered.

It frequently happens that by the third or fourth day the graft has entirely disappeared, but becomes again recognizable a few days after. This is due to the desquamation of the opaque corneous layer of the transplanted cuticle leaving only the thin transparent Malpighian layer behind; the re-appearance of the graft takes place as soon as sufficient new epithelium has grown to be again opaque.

The adhesion of the graft is very greatly facilitated by some form of antiseptic dressing. Perhaps the best is as follows: if the sore be not aseptic dress it every four hours with boracic acid lint moistened with a concentrated solution of boracic acid. In about forty-eight hours the sore will be absolutely free from any septic matter. Then apply the grafts, covering each with a piece of "green protective" oiled silk, and dress the sore with a thin layer of boracic acid ointment spread on muslin and dipped in the boracic acid solution before being applied. Over this again must be placed a thick layer of iodoform cotton wool, or salicylic wool or silk, and the dressing may then be left undisturbed for four days.

For the success of this little operation, it is necessary that the granulating surface on to which the transplantation is made, be a healthy one; that it be not the seat of specific disease of any kind; and that the process of cicatrization have commenced at its edges. The piece of transplanted skin should be tenderly handled, and at once applied and retained by moderate pressure. In placing it in its new position, it is well that the granulations be not bruised, so as to be made to bleed, which would be fatal to success. It is better to apply several small grafts of skin than one large one; each new graft acting as a centre for the growth of epithelium, and the process going on more rapidly from several small centres than from one large one.

When many grafts are required, and especially if the patient be old or nervous, it may be convenient to obtain some from another person. It must not be forgotten that syphilis may be communicated in this way if the grafts are taken from a person suffering from that disease in its active stage. Deubel records a case in which, to repair great loss of skin from gangrenous erisypelas in an old man, grafts were taken from his son. The treatment was apparently successful, and complete healing took place, but soon after spreading ulcers formed, and the whole scar was destroyed. Roseola appeared ten weeks after the first graft was applied, and was followed by mucous tubercles in the mouth. The son was found to have condylomata about the anus, and had suffered eighteen months before from a hard chancre.

Weak Ulcer.—This most commonly occurs from emollient applications having been continued too long, and especially from the application of poultices. It differs from the healthy sore only in the *edges* wanting the healing line, and in the *surface* being raised above the surrounding skin and covered by flabby granulations, with a semi-transparent appearance about them, sometimes rising in large, exuberant, gelatinous, reddish-looking masses above the surface of the sore. These high granulations have a feeble vitality, and readily slough. Popularly they are spoken of as "Proud flesh."

The *Treatment* of this form of ulcer consists in keeping the part elevated and carefully bandaged, and applying an astringent dressing to the sore, such as the "red wash," or a weak solution of the sulphate of copper. Red wash is prepared according to the following formula:—Sulphate of zinc, sixteen grains; compound tincture of lavender, two drachms; water, eight ounces.

It will be found a most useful application. The granulations may also be touched from time to time with nitrate of silver.

Indolent or Callous Ulcer.—This is always very chronic. It is situated on the outer side of the lower extremity, between the ankle and calf, and most frequently occurs in men about the middle period of life. The *surrounding skin* is congested, and usually presents the appearances indicative of long continued passive hyperæmia, being frequently darkly pigmented and always indurated. The induration affects the subcutaneous areolar tissue, which is solid and brawny, and firmly fixed to the subjacent fascia, or in some cases even to the bone. There is a total loss of elasticity, both in the skin and subcutaneous tissue. The epidermis is often scaly and desquamates in large flakes. In many cases the cause of the mischief will be found to be varicose veins, which have given rise to chronic congestion of the skin. The *edges* of the sore are often irregular; they are hard, elevated considerably above the surface of the sore, and sink abruptly into it. The *surface* is either smooth and covered with a yellowish layer, or irregular and formed in parts of pale, badly formed, feeble granulations. The *base* is hard, and firmly fixed to the subjacent fascia or bone. The *discharge* is thin and sanious. There is no pain attending this ulcer, and its surface, which often attains a very large size, may usually be touched without the patient feeling it.

It is always slow to heal, for contraction forms an essential part of the healing of a sore; in the callous ulcer the rigidity of the surrounding tissue renders contraction almost impossible.

Treatment.—The principle of treatment here is to soften the surrounding tissues and depress the edges of the sore by promoting absorption of chronic inflammatory products with which they are infiltrated. When this is accomplished, contraction becomes possible, and healing will progress. This is best effected by pressure.

An old and very efficient plan of treatment is as follows. The treatment should be commenced by rubbing the surface of the ulcer and the surrounding congested integument with nitrate of silver; a linseed-meal poultice, or better, three or four layers of boracic acid lint dipped in hot solution of boracic acid and covered with oiled silk and cotton wool, should be applied and changed every four hours. After twenty-four hours of this treatment the sore should be properly strapped on the plan recommended by Baynton. The best plaster for this purpose is the *emplastrum saponis*, to which some of the *emplastrum resinæ* is added to make it sufficiently adhesive; this, spread upon calico, should be cut into strips sixteen or eighteen inches in length, and about an inch-and-a-half in width; the centre of the strip should then be laid smoothly on the side of the limb opposite to the sore, and the ends, being brought forward, are to be crossed obliquely over it. Strip after strip must be applied in this way, until the limb is covered for a distance of a couple of inches above and below the ulcer. If the sore be near the ankle, this joint should be included in the strapping. Each strip of plaster should be applied with an equal degree of pressure, which may often be considerable, and it should cover at least one-third of the preceding strap; the limb must then be carefully bandaged from the toes to the knee. The plaster will be found to apply itself more evenly if it be warmed by being dipped in hot water instead of the ordinary plan of using dry heat.

Under this plan of treatment, the edges will subside, the surface of the

sore will become florid, and granulations yielding abundant discharge will speedily spring up. Much of the success of this plan of treatment will depend upon the close attention that is paid to it. If the skin be irritable, no resin-plaster should be used, but merely the soap or lead; and the plasters should be changed at least every forty-eight hours. If the discharge be very abundant, small holes should be cut in the strips to allow it to escape. When by this mode of treatment the edges of the sore have been brought down, and the granulations sufficiently stimulated, an astringent lotion with bandaging may advantageously be substituted for the plasters. The great difficulty in carrying out this treatment in hospital out-patient practice, in which the patient is usually seen only twice a week, arises from the foul state into which the sore gets in the intervals of strapping, and consequently it is very important to employ if possible some antiseptic mode of dressing. In order to do this, the first necessary step is to disinfect the sore, which when first seen is usually very foul. This is by no means so easy as might be supposed. It can be done by the free application of chloride of zinc (gr. 20 to ℥j), but this is very painful; another plan is the application of a hot boracic acid dressing as before described, changed every four hours, for two days, and this is very efficient if the patient can only be trusted to do it. Perhaps the best plan is to powder the whole surface of the sore with iodoform in crystals; this is efficient, simple, and as a rule painless. When the sore is quite clean it may be dressed as follows: apply a small sprinkling of powdered iodoform, over this place a piece of protective green oiled silk, then strap the limb, heating the strips of plaster by dipping them in a hot solution of carbolic acid (1 in 40), then apply a carbolic or eucalyptus gauze bandage from the foot to the knee to protect the skin, over this put a thick pad of carded oakum to absorb the discharge, and over all place a common calico bandage. The improvement that results from this treatment is often most surprising.

Another mode of applying pressure has lately been introduced by Martin, of New York. It consists simply in the application of a bandage made of pure india-rubber, free from sulphur. The bandage is applied directly to the sore, no dressing being used when it is on. It is worn only by day; and at night some simple dressing, *free from grease*, may be used. The bandage is thus applied; before rising from bed in the morning, the patient rolls the bandage round the leg, taking care not to pull it in so doing. It must only just lie smoothly on the limb, for any traction might seriously impede the circulation. The patient now rises from bed, and the slight increase in the size of the limb from gravitation of blood into it tightens the bandage sufficiently to make it keep its position. At night the bandage is removed, sponged with warm water, and hung up to dry. The leg must also be carefully washed, and the sore may be dressed with some simple lotion. The only inconvenience of the treatment is, that from the obstruction to the escape of the perspiration, eczema is frequently set up. This is best treated by some oxide of zinc powder, and usually, after a short time, the leg seems to become accustomed to the presence of the bandage, and no further trouble is experienced. This treatment is usually very successful, especially in cases complicated by the presence of varicose veins.

Another mode of treating chronic ulcers is that which was recommended by Syme, consisting in the application of a blister to the indurated edges, and the surface of the sore, after which some simple dressing is used. This is often

efficient, but if the sore be of any considerable size, it is possible that the patient may absorb sufficient cantharidin to cause symptoms of poisoning.

Irritable Ulcer.—This is met with mostly after the middle period of life. It is usually of small size, and situated behind one or other malleolus. The *surrounding skin* is usually purple, slightly indurated and sometimes pigmented; the *edges* are slightly raised, very irregular in outline, and present no signs of healing. The *surface* is but slightly below the level of the skin; it is either dark purplish-red in colour or covered with a thin slough. The *base* is but slightly indurated. The *discharge* is scanty and thin. The *pain* is the principal characteristic; it is exceedingly great, and usually worse at night, thus preventing sleep and seriously disturbing the general health. In fact, such an ulcer, if unrelieved, may bring the patient into so exhausted a condition that death may occur from some apparently slight ailment, such as an attack of bronchitis. Hilton pointed out that if the surface of the sore be carefully touched all over with the point of a probe, one or more spots will be found most acutely tender. This is due to the exposure of a nerve-ending on the surface of the sore.

In the *Treatment* of this ulcer, we must attend to the constitutional as well as to the local condition. The patient should be put upon an alterative course of medicine, with aloëtic purgatives, and some sedative at bedtime to procure rest. The mode of topical medication which I have found to succeed best, is to brush the surface of the sore and the surrounding parts from time to time with a strong solution of nitrate of silver (gr. x to ℥i.), and then to keep emollient and sedative applications applied to it, such as lead and opium lotions. If this does not succeed, the surface of the sore may be rubbed with nitrate of silver until a distinct slough is formed. This treatment is very painful, and may require an anæsthetic; but the smarting soon ceases, and the patient will often enjoy after it the first good night's rest he has had for months. Hilton recommends that the tender spot should be found, and a knife or lancet point passed under it, so as to divide the branch of nerve passing to it. This treatment is often successful, and is less painful than that by nitrate of silver.

Inflamed Ulcer.—This is characterized by redness, swelling, heat, and pain in the *surrounding skin*. The *edges* are sharply cut. The *surface* is at first often dark red and dry from stasis in the vessels of the granulations, but later on it becomes covered by a thin yellow slough. The *base* is swollen and œdematous, like the surrounding tissues. The *discharge* is serous and often bloody. In the most acute stage the surface of the sore may be dry, and covered with a thin crust or scab. It arises most commonly in people who drink to excess, and is not unfrequently associated with gout. Any sore may, however, become inflamed if neglected and allowed to become covered with acrid and putrid discharges.

The *Treatment* must be both general and local. As a rule, the patients are better for purging. This may usually be effected by a mercurial pill, followed by sulphate of magnesia, ʒss, infusion of quassia, ℥i, three times daily for a few days. If the patient be gouty, ten drops of vinum colchici may be added to each dose. Locally the limb must be elevated, and the patient kept in the recumbent position. Hot applications will be found always to give the greatest relief. Hot boracic acid fomentations usually speedily reduce the pain and swelling. Another excellent application is the following: acetate of lead, ʒss;

laudanum, ℥ss ; water, to ℥viij. ; pour a small quantity of the lotion into a saucer and add an equal quantity of boiling water ; moisten with this diluted lotion a piece of lint of sufficient size to cover the whole reddened area ; apply it warm and cover it with oiled silk, then wrap the whole part in a sheet of cotton wool. We thus get warmth and moisture, with a powerful astringent and sedative, and experience has shown that the quantity of acetate of lead present is sufficient to prevent any decomposition of the discharges. If preferred, tincture of belladonna may be substituted for the laudanum.

Sloughing Ulcer.—When not specific, this is an increased degree of the inflamed variety, usually occurring in feeble or cachectic states of the constitution, and generally accompanied by a good deal of fever. The *surrounding skin* presents an angry, dusky, red blush ; the *edges* are sharply cut ; and the *surface* is covered by a greyish slough. The *discharge* is serous ; there is a sense of heat and pain, and the inflamed area is acutely tender. The ulceration, unless arrested, spreads rapidly.

Treatment.—The general health must be improved by a nourishing, but unstimulating diet, combined with the use of tonics. Opium is of the greatest value. One grain should be given twice or thrice daily. The patient must be put to bed, and the part elevated. If the surface of the sore be very foul, it may be sprinkled with iodoform, after which hot fomentations must be applied to the whole reddened area. As the inflammation becomes less acute, the warm lead and opium lotion above mentioned may be applied, and when the sloughs have separated, and the surface has become clean, the ordinary treatment of a healthy sore must be adopted. See Chapters on Hospital Gangrene.

Eczematous Ulcer.—This term is applied to those ulcers in which the *surrounding skin* is affected by eczema ; it is red and at first covered by minute vesicles ; these burst, and a raw-looking surface is left, on which the corneous layer of the epithelium is wanting. It discharges an abundant, yellow, serous fluid, strongly alkaline in reaction, which stiffens any linen rag which may be applied to soak it up. The ulcer itself presents nothing peculiar, and may assume any of the forms already described. The ulceration may arise as a secondary complication of eczema, or the irritation of the skin by the discharge from a badly tended ulcer may be the cause of the eczematous eruption.

Treatment.—The boracic acid ointment, prepared with vaseline and paraffin, will usually be found the best application to the eczematous ulcer. If there is much irritation, it can often be allayed by the addition of half a drachm of extract of belladonna to each ounce of the ointment. Strict cleanliness is at the same time essential, but in washing the limb common soap must never be used ; warm water alone, or with a small quantity of soft soap, will be found the best application. If the patient be gouty, the usual remedies for gout must be administered.

Varicose Ulcer derives its chief characteristic from being complicated with, or dependent upon, a varicose condition of the veins of the leg. In this affection of the venous trunks the skin gradually undergoes degeneration, becoming brawny, of a purplish brown colour, and being traversed in all directions by enlarged and tortuous cutaneous veins. The ulcer forms at one of these congested spots, by the breaking down of the already degenerating tissue, producing a small irregular chasm of an unhealthy appearance, and

varying much in character, being sometimes inflamed, at others irritable or sloughy, and then becoming indolent. One of the most serious effects of this ulcer is that, by penetrating into one of the dilated veins, it occasionally gives rise to very abundant hæmorrhage; the patient in the course of a few seconds losing a pint or two of blood. The hæmorrhage comes chiefly from the proximal side, in consequence of the incompetence of the valves in the varicose veins. It may be readily arrested by laying the patient on his back, elevating the limb, and compressing the bleeding point with a pledget of lint and a roller.

The *Treatment* of a varicose ulcer must have special reference to the condition of the veins that occasions it; no local applications having much effect unless the pressure of the column of blood in the dilated vessels be taken off the part. This may be done by means of a well-applied bandage, made of elastic material, or a laced or elastic stocking applied to the leg, so as to keep up uniform pressure upon the distended vessels. Martin's india-rubber bandage, already described in the treatment of the chronic ulcer, will be found especially useful in the treatment of this form of ulcer. It has the great advantage over the elastic stocking of being suited for application over the ulcer, as it does not become foul by use, and, moreover, if it be properly put on, the pressure is more uniform. In many cases, the cicatrization of the ulcer cannot be brought about by these modes of treatment; or, if the ulcer heal, it constantly breaks open again: or hæmorrhage may occur from a ruptured vein upon its surface. Other means, which will be described in a future chapter, must then be taken for the permanent occlusion of the varicose vessels. As this procedure, however, is attended by some danger from the occasional induction of phlebitis or erysipelas, it should not be had recourse to unless the existence of one or other of the conditions just mentioned urgently calls for it.

Hæmorrhagic Ulcer.—This is a dark purplish-looking sore, which occurs in women suffering from amenorrhœa, and has a special tendency to ooze blood about the menstrual periods, whence its name. It usually partakes of the character of the irritable ulcer.

Treatment.—The hæmorrhagic ulcer requires to be treated by constitutional means, having for their object the improvement of the patient's general health; with this view, the preparations of iron and of aloes are especially useful.

Ulcers on Mucous Membranes.—Various forms of ulcers occur upon mucous membrane, especially those of the throat, rectum, and genital organs. As these, however, are commonly specific, they will be described hereafter.

When ulcers of the mucous membrane are not of a specific character, they present the general appearances characteristic of the cutaneous healthy, inflamed, or weak varieties, and require the topical applications which have been described as suited to these conditions; though generally they will demand the free employment of caustics, or astringents, especially of the nitrate of silver.

CHAPTER VII.

THE PROCESS OF REPAIR.

Having, in the preceding chapters, described certain pathological conditions in which interference with normal nutrition and destruction of tissue form the most prominent features, we have now to give a summary of the processes by which repair takes place.

It will be most convenient to consider repair, firstly, as it is seen in the process of union of a simple wound, the surfaces of which can be brought accurately in contact with each other; and, secondly, as it takes place in wounds in which the loss of substance renders this impossible, or in which the injury is such that an adherent portion of dead tissue must be cast off before any repair *can* take place.

Five different modes of repair have been described as occurring in the union of incised wounds. 1. **Immediate union** or direct growing together of the opposed surfaces. 2. **Union by primary adhesion**, through the medium of a coagulable exudation from the opposed surfaces. 3. **Scabbing**, in which one of the above processes occurs beneath a scab formed of the dried discharges. 4. **By granulation**, in which granulation-tissue springs up from the bottom and sides of the wound, and eventually becomes covered by an epithelial layer; and 5. **By secondary adhesion**, in which two granulating surfaces, being placed in contact, grow together. The two first of these methods of repair are included under the term "union by the first intention," and are confined to incised and punctured wounds. The third is in reality merely an accidental condition attending union by the first intention. The last two may occur in incised wounds if union by first intention fail, and are the only means by which contused and lacerated wounds, with some rare exceptions, have been known to heal.

1. **Immediate Union.**—The direct growing together of opposite surfaces, "without any intervening substance, such as blood or lymph," was first described by James Macartney, of Dublin, in the year 1838. He was led to the opinion that such a process occurred by the observation of cases in which all the coarser signs of inflammation, redness, swelling, heat, and pain, with exudation, were wanting. John Hunter had believed that the bond of union in such cases was the extravasated blood. He thus described the process as he believed it to occur. "The mouths of the vessels are soon shut, either by inosculation, or their own power of contraction," "and if there should be any superfluous extravasated blood, we know that it will be afterwards absorbed. The blood being alive, this uniting medium becomes immediately a part of ourselves, and the parts not being offended by it, no irritation is produced. The red particles are absorbed, and nothing but the coagulating lymph is retained, which, being the true living bond of union, afterwards becomes vascular." The means of observation in the time of John Hunter were inferior to those of Macartney, yet there seems little doubt that his description, erroneous as it

is, contained far more truth than that of the later observer. During the last fifteen or twenty years the means of studying such processes have been greatly improved ; and there can now be no doubt that such a mode of union as that described by Macartney never takes place. It is impossible to make a wound in any vascular part without sufficiently damaging the tissues to cause a coagulable exudation to take place, which, mixed with wandering cells, forms the first bond of union between the opposed surfaces. The quantity of this exudation may, however, be so small that it can be recognized only in microscopic preparations, cut, stained, and mounted, according to the modern methods ; and it is not surprising, therefore, that it escaped the notice of former pathologists.

2. **Union by primary adhesion** (Paget), **primary union, union by adhesive inflammation** (Hunter), or, as it is more commonly called, **Union by the First Intention**, is that form of union which occurs without the formation of pus, and in which the accompanying inflammation is purely traumatic, being strictly limited to the tissues directly injured in the production of the wound. It is the form of union which the Surgeon aims at obtaining in all wounds unaccompanied by extensive loss of substance, or by such a degree of injury of the surface as to cause sloughing.

In order that primary union should take place, the following *conditions* are necessary :—1. That the wound be not contused or lacerated to such a degree as to cause visible sloughing of the surfaces. 2. That the patient's constitution be in a healthy state. 3. That the interposition of all foreign bodies be carefully guarded against. 4. That the wound be closed, and its sides brought into accurate apposition. 5. That the surfaces after being brought together shall be kept at perfect rest. 6. That no cause of inflammation shall be introduced which shall tend to prolong the process beyond the period necessary for the effusion of healthy plastic exudation, or to make it spread beyond the area actually injured by the knife.

In studying union by first intention, it is essential to bear in mind the condition of the surface of a clean incised wound immediately after its infliction. The mechanical violence inflicted on the tissues by the instrument by which the wound was made, the exposure to cold air, and in the present day in many cases the application of some irritating chemical antiseptic, have all combined to damage the exposed tissues, and to lower their vitality to a degree sufficient to give rise to the process of inflammation. Here and there in individual cells or microscopic layers of tissue it is most probable that the damage is sufficient to cause actual death. In the whole of the immediate surface of the wound the vitality is lowered to a degree sufficient to cause stasis ; immediately beyond this we find retarded flow with exudation of liquor sanguinis and migration of the white corpuscles, and beyond this again is an area of simple vascular dilatation—the degree of damage necessarily diminishing as we recede from the parts directly touched by the cutting instrument. The thickness of the layer of tissue thus injured must necessarily vary with the sharpness of the instrument with which the wound was made, the original vitality of the tissues, the amount of violence done in cleaning the wound, the time of exposure to cold air, and the nature of any chemical antiseptic that may be applied to it ; but in most cases of cleanly cut wounds, it is in all probability merely microscopic. This condition of lowered vitality is, except in the microscopic shreds of tissue before alluded to, merely temporary ; and, if no further cause of

damage be introduced, it will pass off in from twelve to twenty-four hours, when all the phenomena of inflammation which occur as a consequence of it will subside.

This being the condition of the surfaces of the wound, the early phenomena of union by first intention are readily explained by the application of the description of the process of inflammation already given. Hæmorrhage is first arrested. In the larger vessels this is effected by artificial means to be discussed hereafter, but in the smaller it occurs spontaneously. The mechanical stimulation caused by the cutting instrument causes a contraction of the smaller arteries extending some little distance from the surface of the wound, and amounting to complete or almost complete closure, and thus the rapidity of the capillary circulation supplied by them is retarded, and its force diminished. Such blood as finds its way into the wounded capillaries when it reaches the damaged area shows the phenomena of stasis. The red corpuscles adhere to each other, and to the wall of the vessel, and plug its lumen, and at the most damaged part where the vessel is divided the condition passes on to definite coagulation, and a small adherent clot is formed, which closes the open mouth of the capillary. The contraction of the arteries is merely temporary, and soon passes off, giving place to dilatation; but by the time this takes place, the clots in the divided capillaries are sufficiently firm and adherent to prevent a recurrence of the hæmorrhage. The fulness of the vessels resulting from the arterial relaxation is readily observable, and is indicated by the blush of redness, with slight swelling, always seen in the edges of a wound a short time after its infliction. This redness is not limited to the area actually injured by the knife, but extends to some distance, often one inch or more from the edge of the wound. The causes of this extensive blush of redness are, firstly, the stimulation of the sensory nerves consequent upon the wound, which, as we have before seen, causes vascular dilatation in the area supplied by the nerves acted on; and secondly, the mechanical obstruction to the circulation caused by the obliteration of the vessels divided in the wound. The blood-pressure being thus increased, while at the same time the vitality of the walls of the vessels has been lowered or suspended in the injured area, abundant effusion of coagulable exudation, with escape of a greater or less number of red corpuscles and rapid migration of the white, sets in; and the exudation, finding a ready way by the open lymph-spaces, pours out on the surface of the wound. Here it coagulates; the fibrine entangling innumerable white corpuscles in its meshes, mixed with a variable number of red, remains adherent to the surface, while the serum, darkly stained with red corpuscles, drains away. It is seldom in the present day that an opportunity is obtained of watching with the naked-eye appearances of this process, as wounds are almost invariably closed as soon as possible after their infliction; but formerly many Surgeons left wounds open, to become "glazed," as it was called, before bringing them together. In an amputation wound treated in this way the process of exudation can be watched; drops of reddish serum accumulate here and there on the surfaces of the flaps, like beads of perspiration in profuse sweating; these by coalescence with others, and by gradual increase, reach a certain size, and then trickle off the surface of the exposed wound, like drops of rain down a window. After this process has lasted an hour or two, the surface of the flap begins to assume a glazed appearance, the "glaze" being formed of the coagulated fibrin mixed with corpuscles as above

described. This material, to which in the present day the term "*plastic exudation*" is perhaps most conveniently applied, is spoken of also as "*coagulable lymph*," "*inflammatory lymph*," or "*lymph*." After the process has continued for some time, the serum, which was at first almost as red as pure blood, becomes almost colourless, and diminishes greatly in quantity. The two flaps, being now covered by the adhesive plastic exudation or lymph, adhere to each other readily with a certain degree of firmness if brought together, and thus a temporary union is obtained, which provides for the perfect rest and apposition necessary for the permanent growing-together of the opposed surfaces. The cessation of the exudation occurs as soon as the damaged tissues recover their full vitality. The plastic exudation, just like a blood-clot, becomes gradually dryer and firmer as the serum drains completely away from it. Any microscopic shreds of tissue which may have been killed outright by the injury become imbedded in the plastic exudation, and are finally absorbed by the wandering cells without causing any suppuration or other disturbance. This process of temporary union should be complete at the end of from twelve to twenty-four hours, the time varying with the size of the wound and the amount of damage done to the tissues in its infliction or in its treatment. If the surface of the wound be washed over with some strong antiseptic solution, such as carbolic acid lotion (1 in 20) or chloride of zinc (20 grs. to 1 oz.), both the quantity and the duration of the exudation will be increased; but even then it should practically cease at the end of twenty-four hours. In large irregular wounds in which it is impossible to obtain perfect apposition a small quantity of serous discharge will continue to escape from the surfaces not in contact, a condition which must necessarily occur in all surfaces in the living body not provided with an impermeable epithelial covering.

A wound in which union by first intention is taking place, if removed at the end of twenty-four hours and examined by microscopic sections, presents the following appearances. The vessels on each side, if they have not emptied themselves after the specimen was removed, are seen to be distended with blood, and their actual divided extremities to be filled with small clots. Outside the vessels a few wandering cells are recognizable, increasing in number as the actual wound is approached. The original cells of the part show no change. Between the surfaces of the wound, the plastic exudation glueing them together is seen as a closely packed mass of small round cells (leucocytes) between which the coagulated fibrin is not recognizable, as it is concealed by the cells. Here and there are groups of red corpuscles or small patches of blood-clot, varying in amount with the perfection with which the capillary hæmorrhage was arrested before the surfaces of the wound were brought into apposition.

So far, therefore, the process of primary union is merely one of inflammation, resulting from the damage done to the tissues during the infliction of the wound and in the subsequent proceedings of cleaning it, arresting hæmorrhage, and bringing the surfaces together. All these causes are merely temporary, ceasing to act as soon as the wound is brought together. The inflammation is purely traumatic, and as such has no tendency to persist nor to extend beyond the area originally injured. It reaches its highest stage within a few minutes of the infliction of the wound, in fact, as soon as the temporary contraction of the arteries passes off and is succeeded by dilatation; and its natural course is to

subside gradually as the tissues recover from the damage done to them at the time of the injury.

The process of union by first intention will be disturbed or entirely prevented by the introduction of any cause which will prolong the inflammation or make it assume a spreading or infective character. Under these circumstances the transudation of liquor sanguinis and the migration of the white corpuscles will continue, and instead of the thin layer of dry firm plastic exudation, composed merely of living corpuscles entangled in the meshes of the coagulated fibrin, there will be a soft exudation, excessive in quantity, the more superficial layers of which will soften and break down into pus, a fluid layer thus being interposed between the surfaces of the wound, effectually preventing primary union.

Amongst the causes which lead to persistence of inflammation in a wound and consequent suppuration, the following may be mentioned as the most common.

1. The nature of the injury ; a blunt or jagged weapon may so damage the tissues as to cause actual death of a layer of some thickness, which must be separated by a process of ulceration and suppuration (see p. 255).

2. The tissues themselves may be feeble either from general or local causes, and consequently possess a diminished power of resisting injury and of rallying from its effects.

3. The raw surfaces may be constantly rubbed against each other if the wounded part be not kept at perfect rest, and the mechanical irritation from this cause is quite sufficient to maintain the process of inflammation.

4. If proper provision be not made for the escape of the serum that necessarily flows from the fresh wounded surface, the cavity of the wound becomes distended by it, and not only are the surfaces separated from each other, but they are exposed to the irritation of *tension*, and while this is acting the inflammatory process cannot subside, but the exudation will continue and intensify the evil, the cavity of the wound coming to resemble that of an acute abscess. Tension from tight stitches causes a similar persistence of the inflammatory process.

5. If in such an undrained wound the causes of decomposition are present, putrefaction of the serous fluid speedily sets in, and the irritating products of decomposition, pent up as they are in contact with the raw surface at some degree of pressure, soak away into the lymph-spaces of the surrounding tissues, and thus cause a spreading inflammation which may extend to a considerable distance beyond the area actually injured by the instrument which inflicted the wound. The firm plastic exudation that is left uniting the surfaces of a well-drained wound being composed almost entirely of living cells is not liable to putrefaction, and any of the ordinary bacteria which may come in contact with it are powerless to produce any evil effect. It need hardly be pointed out that unless decomposable matter, either in the form of excessive blood-clot or pent-up serum, is present in the wound, no decomposition will take place.

6. The persistence of the inflammation may be due to the presence of a foreign body in the wound. A foreign body may give rise to suppuration either from its being in itself irritating, either mechanically or chemically, or from its being porous in character, and thus absorbing serum, which afterwards decomposes. On the other hand, smooth non-absorbent bodies, such as metals, or soft absorbent substances, as unwaxed silk, under successful anti-

septic treatment may become enclosed in a healing wound without causing the formation of pus.

7. Lastly, union by first intention is necessarily prevented by the inoculation of the poison of any of the specific spreading inflammations, as hospital gangrene or erysipelas.

It now remains to trace the process by which the imperfect union by means of the plastic exudation is converted into permanent healing. Although, as we have seen, inflammation is necessary for the formation of the first bond of union, its absence is equally essential for the healthy development of the scar. The first step in the process is the development of new blood-vessels, which penetrate the plastic exudation and finally communicate with similar new vessels from the opposite side of the wound. Small lateral dilatations, or pouches, appear at some points on the walls of the nearest old vessels; these grow out into the plastic mass, bend towards each other, coalesce, and thus form loops. These loops give rise to secondary vascular buds, which follow the same course of development, and thus the vascularisation of the plastic exudation is completed. These buds are not formed by mere stretching of the wall of the vessel; they are true growths from its protoplasm. It is not certain by what means the two buds are guided towards each other until they meet and unite, but it is not improbable that they follow the processes of a branching cell. This process of vascularisation commences as soon as the inflammation ceases. Wywodzoff has found distinct loops commencing to form in a wound in the tongue of a dog forty-eight hours after the infliction of the injury. Probably in a healthy wound the process is completed by the fifth or sixth day. When fully developed the new vessels are very abundant, much more so than in healthy connective tissue. We now have, therefore, as the uniting medium a mass of rounded cells, amongst which ramify innumerable thin-walled capillaries—in short, a thin layer of **granulation-tissue**. Granulation-tissue differs from the "plastic exudation," or "lymph," in containing vessels, and in possessing a homogeneous intercellular substance, instead of the coagulated fibrin which has now disappeared. The cells which compose it are in many cases somewhat larger than white corpuscles, and some may be met with of a branched form. The origin of the cells of granulation-tissue is still involved in some obscurity. Two chief views are entertained concerning them. 1st. That they are developed directly from the migrating white corpuscles by multiplication of these cells after they have taken up their new position outside the vessels. 2nd. That they are developed from the original cells of the part, which commence to divide and multiply as soon as the tissues recover from the temporary damage done them by the infliction of the wound and the consequent inflammation has ceased; the new tissue thus formed replacing the layer of migrated leucocytes and coagulated fibrin which formed the primary bond of union. It is impossible here to give the evidence adduced in favour of these theories; but it is easy to understand how great are the difficulties in the way of the observer; as, in the first place, the migration, which necessarily occurs immediately after the wound, more or less conceals and obscures the original cells of the part, and in the second place, a connective-tissue-corpuscle, if it does multiply, loses its characteristic appearance and assumes the form of a group of small round cells, closely resembling in appearance a collection of migrating leucocytes. Ziegler and Tillmanns have shown that new connective tissue can be developed in small glass capillary chambers

inserted beneath the skin, and in portions of dead tissue inserted in the peritoneal cavity of a rabbit; and on reading the results of their experiments, it is difficult not to believe that the new tissue may be developed from migrating cells. On the other hand, Senftleben has clearly shown that in the cornea by a special mode of experimenting, a loss of substance may be obtained without causing inflammation, and that, under these circumstances, the corneal corpuscles can be seen to take a direct part in the process of repair.

Whatever the origin of the new cells in granulation-tissue may be, the subsequent changes by which the soft, highly vascular cellular mass is converted

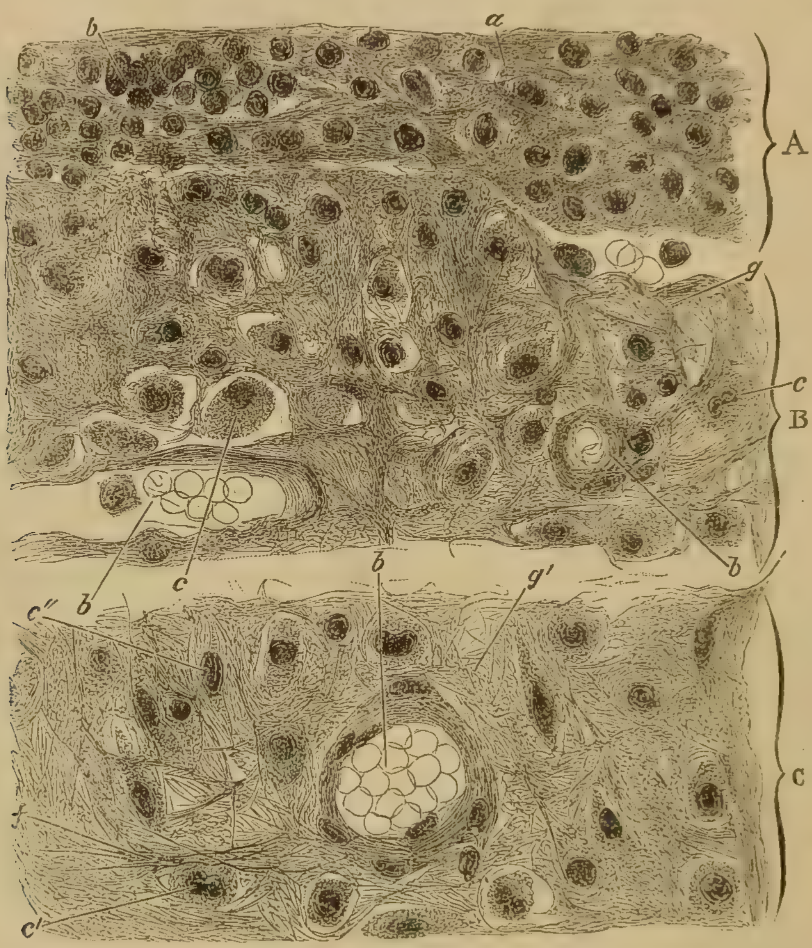


Fig. 100.—Granulation-tissue. × 800. A. Superficial layer just breaking down into pus; *a*, coagulated semi-fluid intercellular substance; *b*, pus-cells. B. Growing layer of granulation-tissue; *b*, blood-vessels, imperfectly developed; *c*, granulation-cells; *c′*, cells with nuclei dividing; *g*, homogeneous ground-substance coagulated by the hardening fluid. C. Deeper layer of granulation-tissue developing into fibrous tissue; *b*, blood-vessel; *c″*, granulation-cells lengthening out into spindle cells; *g′*, ground-substance commencing to fibrillate; *f*, rudimentary fibres.

into the dense, almost non-vascular, fibrous tissue which forms the cicatrix, have been followed with great accuracy. The round cells of which the granulation-tissue is formed first become lengthened out and arranged in lines, chiefly parallel to the vessels. At first between the cells there is merely a little homogeneous intercellular substance, scarcely recognizable, but this gradually increases in quantity and becomes fibrous in structure. How the fibrous tissue is developed is another disputed point; it is uncertain whether it is developed by a direct conversion of the protoplasm of the cells into fibres, or by a process of fibrillation

of the intercellular substance. This much is certain, however, that, as the fibres make their appearance, the cells disappear to a great extent, until at last only a few flattened corpuscles of the form of those ordinarily found in connective tissue are left lying on the bundles of fibres. At the same time a gradual obliteration of the vessels which formed so large a part of the granulation-tissue takes place, until the scar becomes as devoid of vessels as a piece of tendon. Owing to the disappearance of so large a number of cells, and the obliteration of such innumerable vessels, this process of development of granulation-tissue into cicatricial fibrous tissue is accompanied by a considerable diminution in bulk, and thus a scar is always much smaller than the original raw surface from which it resulted. The new fibrous tissue differs from healthy areolar tissue in being more dense, in containing no lymphatics or lymph-spaces, and,

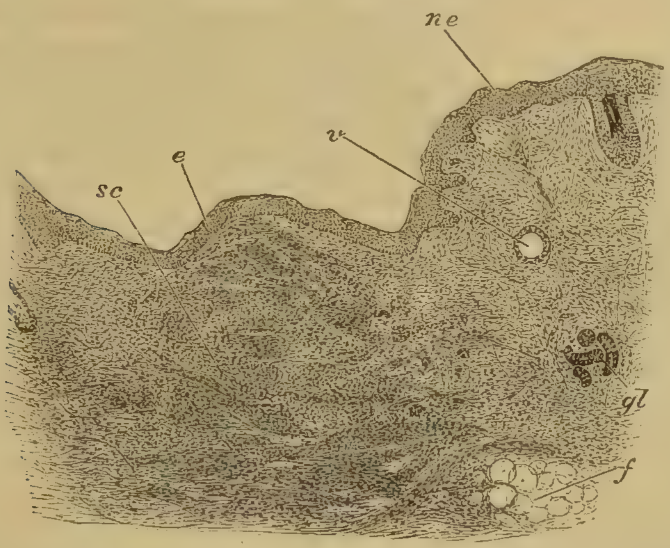


Fig. 101.—A cicatrix, three weeks old after union by the first intention; *e*, new epithelium covering the scar; *sc*, young fibrous tissue containing elongated cells parallel to the vessels; *v*, a vein; *gl*, a sweat gland; *f*, fat. The tissues on each side of the scar contain numerous leucocytes.

in the absence of yellow elastic fibres. It is this that gives a scar its unyielding rigidity and want of elasticity. Very old scars are said gradually to come to resemble normal fibrous tissue more closely, even to the extent of developing yellow elastic tissue.

The **time occupied in these changes** is not accurately defined. We have already seen that the formation of the "plastic exudation," or "lymph," commences immediately after the injury, and under favourable circumstances is finished by the end of the first twenty-four hours. According to Billroth, new vessels can be seen commencing to form within forty-eight hours, and by the end of a week a complete communication is established between the capillaries on each side of the wound. Early in the second week the cells have lengthened out, and the development of fibrous tissue has commenced; and by the end of the second week the superabundant vessels have been partly obliterated, and the new tissue has assumed a considerable degree of firmness. The final obliteration of the vessels in the cicatricial tissue is, as all know, a slow process, lasting many months. Until this is completed the scar remains redder than the surrounding skin, though afterwards it becomes opaque and white.

It is evident that these changes can be recognized on microscopic examination only in those wounds in which the surfaces have been separated from each other by an appreciable layer of plastic exudation or coagulated blood. When the apposition of the surfaces has been more perfect, the layer of uniting material may be so thin as to be scarcely recognizable, and four days after the infliction of the wound it may be almost impossible to recognize any bond of union, the line of the incision being marked only by the presence of a few wandering cells, and some traces of unabsorbed red corpuscles. That true union, however, in such a case has not definitely taken place at this time is shown by the care which is necessary in preserving the specimen for microscopic examination, to prevent the surfaces from separating from each other.

So far we have described only the process of union as it occurs in the deeper parts of the wound. The **repair of the divided epithelium** is a more simple process and is earlier completed. As soon as the surfaces are united by granulation-tissue, new cells are formed from each side by the ordinary processes of growth from the Malpighian layer of the epithelium. The new cells spread over the surface of the granulation-tissue, and soon meet and cover it in ; as the growth continues the superficial cells become corneous, and a perfect restoration of the cuticle is thus accomplished. As the layer of granulation-tissue to be covered over in a wound, the edges of which have been accurately approximated, is merely microscopical, it is evident that in such a case the repair of the epithelial layer of the skin must occur almost immediately after the cessation of the serous discharge. Where there is a wider interval it may be delayed for a varying time according to the width of the surface to be covered, but in all cases it is accomplished long before the complete development of the fibrous tissue of the scar beneath.

In the process of superficial cicatrization, no new papillæ are formed, and it is this which gives a scar its smooth surface.

We have thus traced the development of a scar, and shown that in its formation new blood-vessels, new epithelium, and new fibrous-tissue are developed, and as a rule these structures only form the bond of union after division of the soft parts. In wounds of cartilage, muscle and central nervous tissue, no regeneration of the original tissues takes place, the scar being composed solely of fibrous tissue. Large vessels when completely divided are obliterated and converted into a fibrous cord as far as the nearest collateral branch. As we shall see hereafter, bone is repaired by bone, and under favourable circumstances large nerves are completely united by normal nerve-tissue. In large scars, however, the development of new nervous tissue is very imperfect, if it occurs at all. Little is known of the formation of lymphatics in old scars ; but injections show that they are absolutely wanting in granulation tissue and young scars.

3. **Union by scabbing** does not require any detailed description. The formation of the scab may in fact be regarded rather as a form of occlusive dressing, than as a pathological process. The scab is composed merely of the dried serous discharge, and its formation is favoured by the presence of hair, which becomes matted together and gives toughness and solidity to the crust. A scab also serves to keep the wound free from decomposition, as for its formation the absence of water is necessary whereas the presence of water is essential to putrefaction. When once formed it mechanically excludes the causes of decomposition. For

healing by scabbing the same conditions are necessary as for union by first intention; anything that causes a persistence of inflammation, by leading to continued effusion, will soften or loosen the crust. If the scab forms before the serous effusion has ceased, and thus retains it in the wound, the surfaces will be separated, and tension, causing persistent inflammation ending in suppuration, will follow, which in many cases will be aggravated by decomposition of the pent-up discharge; for although the scab may exclude organisms from without, the wound will probably contain large numbers which have entered before it was closed, and are ready to develope if they find a suitable fluid in which to grow.

In the human subject, therefore, it is only in small, cleanly cut wounds that healing by scabbing is likely to occur; it is, however, more common in the lower animals. The processes that occur beneath the scab are identical with those already described under union by first intention.

The natural process of scabbing is sometimes imitated by the Surgeon when he closes a small punctured wound, such as that of a compound fracture, with a piece of lint dipped in blood, collodion, styptic colloid, friars'-balsam, &c., under which union may take place.

4. **Union by Granulation.**—In those cases in which from the nature of the wound union by first intention is impossible, or in which from the broken state of the patient's constitution, or from some local interference with the process, it fails to be accomplished, healing by "**the Second Intention**," as it is termed, occurs; and we may often see in the same wound one portion unite by primary union and the remainder by granulation. Amongst the injuries in which we look for union by the second intention are included contused and lacerated wounds of all kinds, in which, from the mechanical violence done to the tissues, a layer of variable thickness is completely deprived of its vitality and has to be cast off as a slough by ulceration before the process of repair can commence; incised wounds with loss of so much substance that it is impossible to bring the surfaces into apposition, as after the removal of malignant tumours, and wounds through which some secretion flows, as in lithotomy. Poisoned wounds also must unite in the same way, as they are accompanied by a persistent and often spreading inflammation due to the virus with which they are infected. The raw surfaces following burns and scalds, and the cavities left after removal of dead bone are repaired by the same process.

Union by granulation, although apparently differing so widely from that by the first intention, is in reality accomplished by the same processes modified according to the altered circumstances of the injured part. In union by the first intention we saw that after the surfaces of the wound are brought into apposition and put at perfect rest, every source of irritation is absent, and consequently inflammation with its accompanying exudation ceases as soon as the injured tissues have recovered from the state of lowered vitality into which they were thrown by the injury. In wounds which unite by granulation there is always some source of irritation present which continues to act for a considerable time after the injury, and thus gives rise to a prolongation of the inflammatory process with the formation of pus. Thus, in a simple open wound with loss of substance, the raw surface is exposed to the influence of cold air, to the mechanical irritation of the dressings and to the chemical irritation of antiseptic solutions in some cases and decomposing discharges in

others. In poisoned wounds the specific virus with which they are infected maintains the inflammatory process. In cases of contused and lacerated wounds, or in burns and scalds, the dead tissue serves as the source of prolonged irritation until it is separated by ulceration and thrown off.

The process of union by the second intention is followed most easily in the case of a simple wound with loss of substance so extensive as to render the approximation of the surfaces impossible. The hæmorrhage in such a wound is arrested in the same way as has already been described in treating of union by the first intention, and the same process of exudation takes place. The liquor sanguinis coagulates on the raw surface, the serum drains away, and the fibrin remains behind entangling the migrating white blood-corpuscles in its meshes. In union by first intention, as we have seen, the exudation ceases in a few hours, as the tissues, not having been injured to such an extent as to destroy their vitality and being protected from every source of irritation, speedily return to their normal state. In such a wound as we are considering, however, the raw surface must necessarily be in contact with some foreign material, and is thus exposed to a persistent source of irritation in consequence of which the exudation continues; the migrating cells accumulate on the surface, forming a layer of considerable thickness, and infiltrate the tissues beneath, destroying and taking the place of the superficial parts which have suffered most severely from the injury and the subsequent sources of irritation. The superficial cells of the layer thus formed being exposed necessarily to injurious influences, such as the contact of foreign bodies, the irritation of antiseptic dressings, or of decomposing discharges, &c., perish, become granular, lose their adhesion to each other and float away as pus-cells in the serous discharge. In the pus that is thus formed on the surface of the sore, some freshly migrated white corpuscles still manifesting the characteristic amœboid movements will always be found. While this process of pus-formation is taking place on the surface, development of new vessels, by the process already described under union by first intention, is taking place in the layers beneath, and at the same time there is an active cell-growth which more than compensates for any loss that may be taking place from the surface in the formation of pus, and the loss of substance which resulted from the original injury is gradually repaired. We have thus developed an actively growing layer of granulation-tissue, that is to say, of a tissue composed of small round cells adhering to each other by a homogeneous intercellular substance, and traversed by an abundant system of thin-walled capillary vessels. In a superficial granulating sore the vessels form loops the convex sides of which are directed towards the surface. The same differences of opinion exist as to the origin of the new cells which appear in the process of healing by second intention, as have been already pointed out as existing with regard to the same process in union by the first intention. In whatever way, however, the cells are formed, this much is certain, that "granulation-tissue" is a true tissue, resembling embryonic tissue in its power of growth, by which it fills up the gap left by the loss of substance or formed by the gaping of the surfaces of a wound in which union by first intention has failed to take place. Like any other tissue, "granulation-tissue" is capable of suffering from inflammation if exposed to injurious influences. If removed from every source of irritation, the circulation is as active through the new vessels as it is in those of the original tissues, transudation is not in excess of the requirements of nutrition, and few,

if any, of the corpuscular elements of the blood escape through the vascular walls. The growth takes place by the division of the cells of the granulation-tissue, and not by the addition of migrating corpuscles from the vessels. If the tissue be exposed to injurious influences which lower its vitality, exudation takes place, making the granulations swollen, soft or even œdematous, and multitudes of migrating cells find their way to the surface and float away with the serum

Fig. 102.—Granulating sore, injected. *h*, a hair, *ne*, margin of sore; *e*, new epithelium at the edge of the sore; *c*, a newly-formed vascular loop; *g*, granulation-tissue; *a*, an artery; *v*, a small vein; *gl*, sweat-gland.

as pus, mixed with the superficial granulation-cells which have perished and lost their adhesion to each other. Thus, when on a raw surface a healthy layer of granulation-tissue is formed, it is theoretically possible that the surface may discharge no pus, only a small quantity of serous fluid escaping owing to the want of an impermeable epithelial covering. In order that this may occur, the delicate cells of which its surface is composed must be protected from every possible source of irritation, whether physical, mechanical or chemical. Such a condition it is practically scarcely possible to obtain, but experience of modern methods of dressing has shown that by proper treatment the quantity of pus and the number of corpuscles it contains may be greatly reduced, and the abundant discharge of thick creamy pus is no longer regarded as an essential sign of health.

The new granulation-tissue, formed by healthy growth without inflammation, is of considerable density and firmness, being capable of withstanding some degree of mechanical violence without breaking down. This may be observed on any perfectly healthy, granulating sore by striking the surface

with the finger, when it will be found to stand quite a severe blow without rupture of its vessels. On the other hand, when it is swollen by inflammatory exudation a very slight degree of violence suffices to disintegrate its structure. In fact, it may be laid down as a rule, that granulation-tissue is soft in direct proportion to the amount of irritation to which it is exposed; and as the repair of every injury accompanied by solution of continuity, whether sub-cutaneous or superficial, is accomplished through the medium of granulation-tissue, the importance of bearing this in mind is very great.

The subsequent development of granulation-tissue into the fibrous tissue of the scar differs in no respect from that already described under union by the first intention. In union by the second intention, however, the effects of the contraction that accompanies the process are proportionately more marked as the quantity and extent of granulation-tissue is greater. The amount of the contraction varies with the size of the sore and the looseness of the structures in which it is seated. Thus the scar left by a sore the size of a half-crown on the scrotum might be little more than a quarter of an inch in diameter, while on the face it would probably be about the size of a sixpence, and on the thigh, where there is little skin to spare, it would be about the diameter of a shilling. The fearful deformity produced by the contraction of extensive granulating surfaces in the process of healing is best seen after burns and scalds. This process of contraction is an essential part of healing—no mode of treatment can prevent it; and if from any cause, such as want of skin or adhesion to bone, contraction is not possible, the sore ceases to heal.

The skinning over of the surface of the sore with new epithelium is accomplished by means of multiplication of the cells at the margin of the sore. New epithelium forms from pre-existing epithelium only, and there is no reason whatever to believe that the granulation-cells can develope into epithelial scales.

A scar when fully formed is composed of dense white fibrous tissue, containing few blood-vessels and no lymphatics. It is very imperfectly supplied with nerves, and they may be entirely wanting. The surface is smooth, and devoid of papillæ, sweat-glands, or hair-follicles.

In cases in which a slough has to be separated before repair can commence, this is accomplished by the process described under ulceration (see p. 255).

The clinical phenomena that attend the process above described are as follows. Supposing the case to be one of simple loss of substance produced by a sharp cutting instrument, the raw surface, after bleeding has ceased, continues to discharge a quantity of serum, at first tinged with blood, but gradually becoming colourless; at the same time a glaze is seen to form, due to the plastic exudation adhering to the surface of the wound. The healthy skin around the wound becomes redder than natural, the blush gradually fading away as we recede from the wound. But little further change is observed in the surface of the wound till the end of the second or third day; by this time it is distinctly redder; by the third or fourth day, florid red spots begin to form here and there, and the discharge becomes distinctly purulent. Gradually the red spots coalesce, and the surface becomes covered by the fifth or sixth day with a uniform, highly vascular layer of florid-red granulation-tissue. The surface now is no longer smooth, the new cells being formed around the vascular loops in little heaps, which give it the granular appearance, which has obtained for the new tissue the name of "granulation-tissue."

A typically healthy granulating surface presents the following characteristic features. The separate granulations are about the size of split mustard-seeds; they are uniform in size, and of a florid red colour; they will stand a smart blow without bleeding, and, being devoid of nerves, are perfectly free from sensibility. The surface of the sore is very slightly depressed below that of the surrounding skin. The base of the sore is soft. The edges shelve gradually down into the surface, and, if healing is taking place, the new growing epithelium can be seen spreading over the surface of the granulations, and giving rise to three zones of different colour. Most internally is a dark red line, darker than the neighbouring granulations. This is due to some slightly increased vascularity beneath the growing epithelium, and to the presence of a very thin layer of perfectly transparent new epithelium-cells covering the granulation-tissue. That this is so can be shown by carefully drying the surface, and watching it for a few seconds; the uncovered granulations become moist again almost immediately, while the red line remains dry. Outside the red line is a blue line, resulting from the presence of a thicker layer of epithelium, seen through which the red granulations assume a bluish tint. Outside this again is an opaque white line, in which the new epithelium has been formed in sufficient quantity to be opaque when sodden by the discharges from the sore. The discharge varies with the mode of dressing. If some slightly irritant lotion or dressing be applied, thick creamy pus is poured out from the surface; if some non-irritating dressing be applied, thin serous fluid flows away, made more or less turbid by the presence of a few pus-cells. A granulating sore may present a perfectly healthy appearance with both conditions of discharge, but it will be usually found that the red line of new growing epithelium is much wider in those cases in which the dressing is least irritating, as under other conditions many of the young epithelium-cells perish and mingle with the pus-cells in the discharge.

The constitutional symptoms that attend union by the second intention will vary much. The separation of a slough will in all cases be attended by some febrile disturbance if the dead tissue be allowed to putrefy; by antiseptic treatment, however, this may be entirely prevented, and union by the second intention may be accompanied by as little constitutional disturbance as that by the first intention. In cases in which no antiseptic precautions are observed, the febrile disturbance due to the absorption of the products of putrefaction commences on the second day after the injury, and reaches its maximum by the third or fourth. By this time the lymph-spaces are becoming filled with the plastic exudation and absorption is consequently limited. When the slough is separated and the granulating surface is formed—that is to say, by about the sixth to the tenth day—the fever disappears; as healthy granulations, being devoid of lymphatics, form a barrier to the absorption of septic matter unless it is pent up in contact with them at some degree of pressure.

The changes taking place in a cicatrix, do not cease with its formation. In most cases the contraction of the scar does not attain its maximum until long after the completion of superficial cicatrization, and this may occasion great puckering and deformity. The amount of contraction of a scar is dependent solely on the size of the original raw surface and on the laxity of the tissue in which it is seated. There is not an atom of evidence to justify the assertion so commonly made that the scars resulting from the healing of sores produced by

acid caustics and burns contract more than those following the action of alkaline caustics or superficial wounds. A circular scar round a tubular organ or excretory duct, as in the intestine, œsophagus, or urethra leads to narrowing or stricture of the canal, and many of the worst œsophageal strictures result from the accidental swallowing of caustic alkaline fluids. These strictures in most cases gradually become narrower as time goes on, the process of contraction continuing long after the sore has healed.

Further changes are wrought by time in the texture of a cicatrix. In the first place, its tissue assimilates more and more to the normal structure of the part; and secondly, its deep attachments become more movable. When a scar is first formed, it is thin, reddish, or bluish and shining, being composed of imperfectly developed fibrous tissue, covered by a thin epidermic layer. As it becomes older, it assumes a dead-white colour, and becomes depressed, and gradually, but slowly, many years being perhaps required for the change, it "wears out;" that is to say, its structure more closely resembles that of the texture of the part in which it is seated. It never, however, becomes developed into true skin, as neither sebaceous nor sudoriferous glands nor hair form in it.

Coincidently with these changes, the scar loosens its deep attachments, so that it can be moved more freely upon subjacent parts. It is a long time before the scar attains the vitality of the older structures, if ever it do so completely; and the larger it is, the less its power will usually be. Under the influence of scurvy or syphilis, an old scar is apt to open up again; so also, if a fresh ulcer be formed on the old cicatrix, it will take a longer time to heal than the original one.

5. **Union by Secondary Adhesion.**—It not unfrequently happens that, although granulations spring up over the sides of a wound, union between the opposed surfaces does not take place. We endeavour to accomplish this by bringing the granulating sides together, and retaining them in that position, when they will cohere; this constitutes union by "*Secondary Adhesion.*" In some amputations, and in many plastic operations, cases of hare-lip, cleft-palate, &c., union is occasionally brought about in this manner.

The conditions necessary for this mode of union are, 1st, that the granulating surfaces shall be perfectly healthy; 2nd, that they shall be smooth, so that they can be brought evenly into apposition without leaving cavities between them in which pus may accumulate; and 3rd, that after they are brought together they shall be kept at perfect rest.

On considering the five methods of union in wounds just described, it is at once evident that the Surgeon's best endeavours should be directed towards procuring healing by the first intention, wherever practicable. The patient is not only spared the drain of a more or less prolonged suppuration, with its attendant waste of new tissue-elements, elaborated at the expense of his vital powers, but he is saved also from the dangers to life that must always be associated with an open wound.

Circumstances Affecting the Healing Process.—In concluding this general description of the process of union of wounds, it will, perhaps, be well to recall briefly some of the conditions essential to rapid and certain healing. In the first place, two conditions are absolutely essential, perfect rest and perfect drainage. No wound can possibly heal by the first intention if its surfaces are frequently rubbed against each other, either by the movements of the

injured part or by the clumsiness of the Surgeon in changing the dressings; nor can early union possibly occur if the surfaces are separated from each other by pent-up serous discharge. The third great source of irritation to which wounds are exposed, is the presence of decomposing matter between their surfaces. In order that this should occur, it is hardly necessary to say that there must be some dead matter there to decompose; living tissues do not putrefy, and amongst living tissues must be reckoned the plastic exudation that glazes a wound, and forms the preliminary bond of union. On the other hand the serous discharge which is poured out in the first twenty-four hours is highly decomposable. A perfectly-drained wound with no foreign body in it contains practically nothing capable of decomposing, and if we could always guarantee that a wound should be in this state, no antiseptic treatment would ever be necessary. Unfortunately this is not the case; and, therefore, some form of antiseptic treatment undoubtedly gives an additional certainty in the treatment of wounds, more especially those with cavities such as compound fractures.

Lastly, union may be prevented by the introduction of the specific poison of some infective, spreading inflammation as in some forms of septicæmia, in erysipelas or hospital gangrene. That these poisons are generated in filth, and are destroyed by many antiseptics, may be considered as beyond a doubt; and this forms an additional reason for the habitual employment of these agents. The use of antiseptics cannot make any wound do better than heal by first intention, a result obtained with great frequency in all well-drained wounds kept at perfect rest in healthy subjects; but it can, and does prevent the evil consequences that may result from some accidental failure in drainage, and thus has tended greatly to improve the average results of the treatment of wounds. There are other circumstances, apart from the local conditions with which we have hitherto dealt, that are not without influence on the processes of repair in wounds: the age, temperament, previous state of health and constitution of the patient, his occupation and usual mode of life, the situation in which he is placed after the receipt of the injury, and many other matters, must all more or less affect the result. The scrofulous or scorbutic diathesis, or the presence of amyloid degeneration of the liver, or disease of the kidneys, &c., must always militate against rapidity and perfection of cure. Habits of intemperance and over-indulgence, privation, exposure, bad sanitary and hygienic conditions, are all alike antagonistic to reparative action. These are points to which the Surgeon's attention must be directed, with the view of counteracting them as far as lies in his power by appropriate precautions and treatment.

DIVISION SECOND.

SURGICAL INJURIES.

INJURIES AFFECTING THE TISSUES GENERALLY.

CHAPTER VIII.

CONSTITUTIONAL EFFECTS OF INJURY.

An injury to any part of the body, in whatever way inflicted, is necessarily the direct cause of local effects of a more or less serious character. But besides, and as the consequence of these, it occasions constitutional phenomena. These we shall first consider, and afterwards proceed to the discussion of the local effects of injury.

The Constitutional Phenomena resulting from injury are of two kinds—*Immediate* and *Remote*.

The more Immediate Constitutional effects of injury consist of Shock, followed by Traumatic Fever and Delirium. These we shall first consider. The more Remote Constitutional conditions are of two kinds—those affecting the Nervous System, as Tetanus; and those infecting the Blood through the medium of the wound, as Pyæmia, Septicæmia, &c. These will be treated of subsequently.

The effect of an injury will be greatly modified, according to the condition of the patient at the time of its receipt, and the circumstances in which he is placed afterwards. The remarks made at page 5, in reference to the conditions that influence the results of operations, are equally applicable to those forms of surgical injury that are the result of accident, and not inflicted by the Surgeon's knife: and to these I would refer the reader.

SHOCK.

Shock is a disturbance of the functions of the nervous system, whereby the harmony of action of the great nervous centres, more especially of the sympathetic ganglia, and through them of the various organs of the body, becomes deranged.

Symptoms.—The symptoms of shock necessarily vary according to the severity of the injury, the importance of the part injured, and the nervous susceptibility of the sufferer.

When the injury is not very severe, does not implicate important parts, or occurs in an individual of strong nerve, the symptoms are slight and passing.

A momentary confusion, giddiness, and pallor, with tumultuous action of the heart, and a catch in the breath, may be observed. These symptoms speedily pass off, and are followed by no other effect than a feeling of depression, physical and mental.

But if the injury be very severe, if it affect a vital part, or if the sufferer be of unduly nervous susceptibility, the phenomena are much more marked.

In such cases, the sufferer becomes pale, cold, faint, and trembling; the pulse is small and fluttering; there is great mental depression and disquietude, the disturbed state of mind revealing itself in the countenance, and in feebleness or incoherence of speech and thought; the surface becomes covered with a cold sweat; there is nausea, and perhaps vomiting, and relaxation of the sphincters. In severe shock, the temperature, according to Furneaux Jordan, falls to about 97° Fahr. in the adult. In the young, the fall is less; in the aged, it is greater. I have several times found it below 95° Fahr. in the mouth and the axilla. Wagstaffe has met with cases in which recovery followed a fall of temperature amounting to four degrees. In fatal cases there may be a fall of as much as six degrees. These symptoms commonly set in immediately on the receipt of the injury. In some cases, however, there is an appreciable interval of time between the infliction of the injury and the appearance of the shock; this is more particularly the case in persons of great mental fortitude, or whose minds are actively engaged at the moment of the receipt of an injury. The condition of shock lasts for a variable period, its duration depending on the severity and seat of the injury, on the nervous susceptibility of the patient, and on the state of his mind at the time.

On recovery from the immediate and depressing effects of shock, *secondary phenomena* of various kinds frequently present themselves. These are chiefly such as arise from lesion of the sympathetic system of nerves, and consequent disturbance of its vaso-motor action. Various functional derangements of the brain and spinal cord often manifest themselves; amongst these, headache, sleeplessness, diminution of mental power, and chorea, are the most common. Tumultuous action of the heart, panting and dyspnœa under exertion, congestion of the abdominal viscera, and in some cases hæmorrhages from the intestines, are also amongst the more common secondary phenomena of severe shock, and more remotely we find venous thrombosis. The depression of temperature consequent on severe nervous shock may last for a very great length of time. I have often seen persons who have sustained a severe shock in a railway collision have a surface-temperature from 2° to 3° Fahr. below normal for many months after the accident. During the whole of this period the mind and nervous system continue in a weakened state.

Causes.—The most severe forms of shock are those that arise from gun-shot-wounds and railway-collisions. The severely and deeply penetrating character of the injuries in the one case, and the suddenness of their occurrence, with the terror inspired by them, in the other, explain the severity of their effects on the nervous system of the sufferer. Shock is partly due to *mental*, partly to purely *physical* causes. Its severity and continuance are thus materially influenced by the moral condition of the patient, and by the degree and nature of his injury.

In persons of a very timid character, or of great nervous susceptibility—those who are liable to the occurrence of syncope—more especially in females,

a very trivial injury may produce an extreme degree of shock to the nervous system; indeed, the mere apprehension of injury may, without the occurrence of any physical lesion, give rise to all the phenomena of shock in its most intense degree. People have been actually frightened to death, without any injury having been inflicted upon them. The state of mind at the time of the receipt of the injury, influences materially its effects on the nervous system. If the patient be anxiously watching for the infliction of a wound, as waiting for the first incision in a surgical operation, all the attention is concentrated upon the coming pain; it is severely felt, and the consequent shock to the system is unusually great. If, on the other hand, the attention be diverted—if, as in the hour of battle, the feelings be roused to the highest pitch, and the mind in a state of intense excitement—a severe injury may be inflicted, and the patient may be entirely unconscious of it, feeling no pain, and experiencing no shock, perhaps not knowing that he is wounded till he sees his own blood. The severity of shock, when the brain or spinal cord is not directly injured, is in a great measure proportionate to the degree of pain attendant upon an injury. And, as sensibility to pain varies greatly in different individuals, so will the attendant shock be greater in some than in others. The sensibility of different individuals varies much, and is greatly dependent on occupation, sex, and temperament. Men who live hardy out-door lives are less sensitive to pain than those who follow occupations of an opposite kind. The skin, which is the main seat of sensibility in wounds, when hardened by exposure and work, is less sensitive than when it has been habitually protected from such influences. The higher man rises in the scale of civilisation, the more acute does his sensibility to pain appear to become, or possibly the less well able is he to bear it. A savage probably suffers less than a civilised man from any given injury, and hence may display more fortitude. An hysterical woman probably does not suffer more than one with a more healthy nervous system, but she complains more loudly, for she has her feelings in all things less under control. Race appears to exercise an influence on pain; some of the native races of India appear to suffer far less than Europeans under surgical operations of a similar kind. But there are other conditions besides pain that influence the severity of shock.

Furneaux Jordan has pointed out that the functional activity of the nervous system has an important influence in the production of shock. By young children, he observes, whose force is developmental rather than nervous or muscular, operations and injuries are better borne than by men in the prime of life, where all organs and functions are subservient to the exercise of nerve-force. And the same occurs in persons worn by long-standing local disease, which has lowered the manifestations of vitality without impairing the integrity of the organs essential to life. "Shock," he says, "is essentially a depression or metamorphosis of nerve-force. Where nerve-force is predominant, shock also becomes predominant."

The sudden occurrence of a severe injury will, however, induce a *physical impression* independently of any mental emotion or moral influence. Thus, if a limb of one of the lower animals, as of a frog, be suddenly crushed by the blow of a hammer, the force and frequency of the heart's action immediately become considerably lessened. Here there can be no mental impression. So in man, it is found that the severity and the continuance of the shock are usually proportionate to the severity of the injury, either from its extent or from the

importance of the part wounded. Thus, if the whole of a limb be torn away by a cannon-shot, or crushed by a railway train, the shock will be severe from the extent of the mutilation, though the part injured be not immediately necessary to life; whilst, on the other hand, if a man be shot by a pistol-bullet through the abdomen, though the extent of the injury be trifling, and merely a few drops of blood escape, yet the shock to the system will be severe, owing to the importance in the economy of the part injured. The Surgeon not unfrequently employs this fact as an accessory means of diagnosis. Thus, if a man break his leg, and at the same time strike his abdomen, and the shock be very serious and long continued, without sign of rallying, the probability is that some severe injury has been inflicted upon an internal organ; injury of the viscera occasioning more severe and continued shock than a wound of a less vital part.

In extreme cases the depression of power characterizing shock may be so great as to terminate in death. Jordan describes two kinds of death from syncope, as being produced by shock. In cases where the impression is sudden and violent, the heart is contracted and empty, or nearly so. More frequently, however, there is a sudden arrest of the contractile power of the heart, and its cavities contain more or less partially coagulated blood. In the great majority of instances, however, *reaction* comes on, and the disturbed balance in the system is gradually restored. Not unfrequently the reaction runs beyond the limits necessary for this, and a febrile state is induced, the *traumatic fever*, which will be presently described.

Shock must not be confounded with the effects of concussion of the brain, nor with the syncope that results from loss of blood. It may be associated with, and its intensity materially increased by one or both of these conditions; but it commonly occurs independently of either. It is due to the impression produced on the nervous centres by the violent afferent impulse caused by the injury to the peripheral nerves during the accident. The exhaustion of the nervous centres thus induced is shown by the general state of muscular relaxation, the loss of tone throughout the vascular system, the feeble action of the heart, and the state of semi-unconsciousness into which the patient is thrown. The general relaxation of the vessels throughout the body thus occurring simultaneously with an extremely feeble action of the heart, leads to an accumulation of blood, with partial stagnation in those parts of the vascular system which are most dilatable. This is especially marked in the veins of the abdominal cavity. The lungs are also frequently gorged with blood. The abstraction of so large a portion of the blood from the circulation causes anæmia of other parts, and it is thus that the pallor of the skin and the anæmia of the brain have been explained. This theory, however, though highly probable, is scarcely yet definitely proven.

Pathological Appearances.—There are no characteristic *post mortem* appearances after death from shock. The heart, rarely contracted, is more often found full of blood, especially the right auricle and ventricle, and the whole venous system is somewhat gorged, unless the patient has lost much blood from the accident. The blood was said by Hunter to remain fluid in some cases of death from shock, but this is certainly of very rare occurrence. Rigor mortis is usually well marked. The lungs are engorged, the abdominal viscera congested, but the brain is pale and anæmic.

Treatment.—If the shock be chiefly mental, the patient will usually rally

speedily on being spoken to in a kind and cheering manner, or on having some stimulant administered. If the shock be more severe, and be the result of considerable injury, the patient should be laid in the recumbent position, and the injured part arranged as comfortably as possible; he should be wrapped up in warm blankets, hot bottles should be applied to the feet, and friction to the hands and surface; a little warm tea, wine, or spirits and water, may be administered, provided the insensibility be not complete; if it be complete, the fluid should not be given, lest it find its way into the larynx. In these circumstances, ammonia should be applied to the nostrils, and a stimulating enema administered, or ten minims of ether may be injected hypodermically, and repeated at intervals of about ten minutes if necessary until the patient begins to rally. When there is much pain associated with the shock, a few drops of laudanum may advantageously be given, or a quarter of a grain of morphia administered hypodermically. By such treatment as this, the energies of the nervous system are gradually restored.

Operation during Shock.—A question of considerable importance frequently occurs in these cases; viz., whether an operation should be performed during shock. As a general rule, it certainly should be deferred until reaction comes on, as the additional injury inflicted by the operation would increase the depression under which the patient is suffering. In some cases, however, the presence of a crushed limb appears to prolong the shock, and to prevent the patient from rallying, notwithstanding the administration of stimulants. In these circumstances the Surgeon would be justified in operating before reaction came on. Here the administration of ether is extremely beneficial: it exercises a sustaining influence, not only by acting as a stimulant to the nervous system, but by preventing the pain and dread of the operation from still further depressing the vital energies. In these cases of long-continued shock, great care is required in ascertaining that there is no internal injury, such as laceration of one of the viscera, giving rise to the depression, but that the shock is really and solely dependent upon the mangled state of the limb.

After the immediate effects of the shock have entirely passed away, we must adopt means to prevent the remote consequences. With this view complete rest of body and repose of mind must be enjoined; all business must be laid aside, and if the season admits of it, much time should be spent in the open air. Should nervous symptoms develop, warm sea-water douches or a sea voyage will be found most beneficial. In addition to this, the patient's diet and habits of life should be carefully regulated, over-stimulation being especially avoided; his bowels should be kept freely open, and his general health attended to on ordinary medical principles.

TRAUMATIC FEVER.

After the immediate effects of shock have passed off, the reaction which ensues may not exceed the limits of health; but more commonly, even though the shock may have been but slight, a general febrile state ensues. The exact causes and nature of the febrile condition that follows injuries and surgical operations has occupied the attention of numerous observers, amongst whom may be mentioned Billroth, Bergmann, and Lucas-Championière. The results of their investigations have been to show that there are at least two distinct

forms of febrile disturbance, which were formerly confounded together under the name of "traumatic fever." The first of these, which may be called the true traumatic or reactionary fever, commences as soon as the symptoms of shock disappear. As the patient rallies the thermometer rises from the sub-normal point to which it had fallen, passes the normal, and gradually reaches one or two degrees above the standard of health. In the majority of cases it reaches its highest point on the second day, and falls again by the end of the third day to the natural degree. It is possible to observe this fever clearly only in cases in which the injury is followed merely by the simple traumatic inflammation which is a necessary consequence of an injury. If decomposition of the discharges or spreading inflammation occurs, the simple traumatic fever is more or less masked by the septic or inflammatory fever which accompanies these conditions. Simple traumatic fever is best studied, therefore, in sub-cutaneous injuries, such as simple fractures, or severe bruises of the soft parts. The exact cause of this febrile disturbance has not yet been clearly settled. Lucas-Championière is of opinion that we must look for its cause in the nervous system, and certainly in some cases it is difficult to conceive any other mode of origin. The most marked illustration of a febrile condition apparently of purely nervous origin is that which follows concussion of the brain, when there is no reason to suspect any actual laceration, that is to say, when the insensibility is of short duration and the recovery complete. In such cases it will usually be found that the thermometer rises to about 100° F., and falls again to the normal point within twenty-four or forty-eight hours of the injury.

In other cases the early fever is most probably produced by absorption of the exudation that takes place as the immediate result of the injury. It has been shown experimentally by Billroth and others that the fresh aseptic serous discharge from a recent wound if injected into the subcutaneous tissue or into the vessels of an animal causes febrile disturbance. Köhler, Edelberg, Bergmann, and others, have also shown that the expressed serum from a fresh blood-clot possesses powerful pyrogenic properties which they attribute to the blood-ferment, which it always contains in considerable quantities in a free state. If the ferment be injected in large quantity, other symptoms are developed resembling septicæmia, and often associated with coagulation of blood in the heart, or cardiac thrombosis.

In aseptic wounds and subcutaneous injuries we have therefore three causes which may separately or conjointly produce the condition known as "traumatic fever." Firstly, a nervous disturbance, concerning the exact nature of which it is useless to speculate; secondly, the absorption of the early exudation from a fresh wound; and thirdly, the excessive ferment contained in the serum squeezed from a blood-clot during its contraction.

Aseptic Traumatic Fever seldom lasts beyond the fourth day; during its course the thermometer rarely passes 101° F., and, as in other febrile conditions, the evening- is usually about one degree above the morning-temperature. The constitutional disturbance is very slight, the patient himself being often unconscious of any feeling of illness.

Simple Inflammatory Fever also may occur as a consequence of a wound should the serous discharge or pus be pent up within it, even when decomposition has been prevented; for as before stated, when treating of the constitutional symptoms of inflammation, the exudation fluids that

drain off from an inflamed part by the lymphatics possess pyrogenic properties.

Septic Traumatic Fever is due to the absorption of the chemical products of putrefaction from the surface of a wound. Until granulations which offer an efficient barrier to the passage of septic matter have sprung up, the raw surface left by a wound absorbs it with the greatest readiness. It has been shown by experiment that salts, such as ferrocyanide of potassium, are taken up with great rapidity, and can be detected in the urine within a very short time after their application to a raw surface; the rapidity of absorption is scarcely if at all less from a surface which has been cauterized with a hot iron, but the application of a strong solution of chloride of zinc materially retards, or even prevents the entrance of the salts into the circulation. The presence of septic matter in a wound, in addition to the constitutional disturbance it directly gives rise to, always causes more or less local inflammation, the products of which no doubt aid in producing the fever. The severity of septic traumatic fever is proportional to the dose of the chemical products of putrefaction which enters the circulation; consequently it will vary directly with the amount of septic matter present and the size of the wound. If the decomposing matter be pent up at some degree of pressure, the rapidity of absorption will be increased. Should the dose be sufficient, the patient may die rapidly from the direct toxic effects of the chemical products of putrefaction, a condition which will be described as one of the forms of septicæmia. Between septic traumatic fever and this, the difference is only one of degree. Guided by these facts, the prevention of septic traumatic fever can in most cases be successfully accomplished: first, by perfect drainage of the wound, by which the amount of decomposable matter is reduced to a minimum; and secondly, by the employment of those modes of dressing which will absolutely prevent the decomposition of such discharges as may remain in contact with the raw surface.

Should septic fever occur it commences on the second day, and reaches its highest point by the third or fourth. At this time the temperature reaches 103° F. or 104° F., or even higher. It remains at about the same height with the usual evening-rise and morning-fall till the ninth or tenth day, by which time granulations have sprung up throughout the wound, and the absorption of septic matter ceases more or less completely according to the perfection of the drainage. During the fever the pulse is generally frequent in proportion to the temperature, the disturbance of appetite is great, there are often delirium, especially at night, and rapid loss of flesh. The decline of the fever, or defervescence, is sometimes rapid, occurring in a period varying from twenty-four to thirty-six hours; but should the wound be one in which perfect drainage is difficult, as in a compound fracture, decomposing pus may be still pent up in parts of the cavity at some degree of pressure, and under these circumstances the decline of the fever will be much delayed, and the symptoms may gradually merge into those of "hectic," attended by the marked evening-exacerbations, the profuse sweats, and progressive loss of strength.

TRAUMATIC DELIRIUM.

Traumatic Delirium not unfrequently occurs in cases of severe injury in individuals with an irritable nervous system, particularly in those who have been drinking freely before the accident, or who were intoxicated at the time when it occurred. It usually comes on about the third or fourth day, but

sometimes earlier than this: and most commonly declares itself during the night. It is occasionally met with after operations in cases in which there has been a severe mental strain on the part of the patient previous to the operation. In my experience traumatic delirium more frequently follows removal of the breast than any other operation; more especially in those cases in which the patient has long suffered from and long concealed her disease, and finally with great mental effort submitted to the operation. Two distinct types of traumatic delirium have been described, which are, in fact, two different diseases, the one *inflammatory*, the other *nervous*.

In **Inflammatory Traumatic Delirium** there are a quick and bounding pulse, hot skin and head, flushed cheeks, glistening eyes, much thirst, and high fever; in fact, this form is merely the delirium which accompanies the febrile disturbance consequent upon the absorption of the products of septic or infective inflammations from the wound. Occasionally the patient is violent, tossing himself about the bed, and moving the injured part insensible to or regardless of pain. More often there is mere wandering of mind; and in mild cases the patient will answer questions rationally if spoken to. The symptoms are most marked at night, and diminish when the morning-fall of temperature commences; they usually set in on the third day, and are most marked by the fourth or fifth, which, as before stated, is the time at which septic traumatic fever reaches its highest point. The *Treatment* of this form is best carried out by the application of ice to the head; the bowels must be kept well open, and the diet must be light but nutritious. The use of stimulants must be determined by the state of the pulse; when this is very rapid, alcohol often diminishes the delirium and produces sleep; when it is very full and bounding and the patient is young, bleeding from the arm may occasionally be resorted to, but this is seldom required. The patient must be carefully watched, as there is often a constant desire to get out of bed. At the same time that these measures are adopted, local means must not be neglected to subdue the inflammation, and remove any septic matter or pent-up discharges which may be giving rise to the febrile disturbance.

Nervous Traumatic Delirium usually occurs in persons whose constitutions have been broken by habitual excess in drinking; and in fact, it is in most cases, if not always, an attack of ordinary delirium tremens, induced by the shock of the accident. In some rare cases it is preceded by a fit of an epileptiform character; most commonly the earliest sign is want of sleep, with a restless nervous manner. The pulse becomes quick, small, and irritable; the surface is cool, and usually covered by a clammy offensive perspiration; in cases uncomplicated by an open wound there is usually no elevation of temperature; should there be fever, the gravity of the case is greatly increased. The tongue is white and furred, and there is usually, though by no means always, tremor both of it and the hands. The delirium is of a muttering, suspecting character; the patient is often harassed by spectral illusions, but will answer rationally when spoken to. Traumatic delirium tremens is sometimes very rapidly fatal. I have known it to destroy life in cases of simple fracture in less than twelve hours. In other cases, death takes place after some days from exhaustion; and the fatal termination is occasionally sudden.

In the *Treatment* of nervous traumatic delirium, the essential points are to obtain sleep and to keep up the patient's strength. The excessively foul tongue and breath are sufficient indication of the necessity of administering a

brisk purgative at the commencement of the treatment; in many cases no sedatives will have any effect till the purge has acted. The motions brought away by the medicine are usually excessively foul. The best sedatives are bromide of potassium, morphia, and hyoscyamus. The bromide may be given in twenty-grain doses, repeated every two or three hours. Morphia may be given in quarter-grain doses, repeated at intervals of four hours, till one grain is reached, or till sleep is induced. The effect of the drug must be carefully watched. It is always better to administer it hypodermically when possible, as in some cases it seems to be imperfectly absorbed from the disordered stomach. Hyoscyamus may be administered in half-drachm doses of the tincture, but it is less effectual than morphia. Both morphia and hyoscyamus may be given in combination with the bromide. Hydrate of chloral has also frequently been used; but it is not so safe a drug as those just mentioned, as an excessive dose may kill the patient suddenly. The Surgeon must use his judgment as to the extent to which the sedatives may be pushed. If they fail to act, it is often wiser to discontinue them, than to run the risk of giving a poisonous dose. Food is even of more importance than sedatives; so long as the patient can take an abundant supply of good liquid nourishment, there is hope of his recovery. Solids must be avoided, as the stomach is never in a state to digest them. If there be much depression, it will usually be advisable to administer some stimulant, that to which the patient has habituated himself being the best. It is sometimes convenient to mix the sedative with the stimulant. If the patient be strong, there is no danger in cutting off all stimulants, even in the case of a confirmed drunkard. After sleep has been induced, the quantity of sedatives must be lessened; but it will often be found necessary to continue them for some time, as there will be a tendency to recurrence of the delirium at night.

The patient should if possible be put in a room by himself, and watched by a single attendant. If he is violent, he should be at once put in a strait-waistcoat, as it excites him much less to struggle with an inanimate object, than with a couple of men. When the strait-waistcoat is firmly applied, the attendant should keep out of sight as much as possible while watching him. If the injury is a broken bone in a limb, the injured part must be fixed firmly in splints well padded with cotton wool, and swung from a cradle: it must on no account be fixed to the bed, for every movement of the patient would then grind the bones together, and perhaps render a simple fracture compound. The patient seems absolutely insensible to the pain caused by such movements.

These two forms of traumatic delirium, the inflammatory and the nervous, are often found more or less conjoined, and in such cases the prognosis is always grave, as exhaustion speedily sets in: stimulants and abundant fluid nourishment must then be freely administered.

REMOTE EFFECTS OF INJURY.

These may be *constitutional* or *local*.

The **Remote Constitutional Effects** of injuries are of a very varied character. In some cases, persons who have met with serious injury will be found to die suddenly, some months after apparent recovery. In others, they gradually fall out of health, the nutrition of the body appearing to become impaired,

anæmia and a cachectic state supervening. In other instances, again, the functions of the nervous system become disturbed : convulsive movements or paralytic symptoms of a slight but persistent character eventually develop themselves, and may become progressive, terminating in organic disease of the nervous centres. In these cases, the immediate influence exercised by the injury on the nervous system seems to pass off, while a permanent impression is left. The patient never completely recovers from the effects of his injury: he is never, to use the common expression, "the same man again ;" and, although his health may appear to improve from time to time, yet, on close inquiry and careful investigation, it will be found that there has been a continuous train of symptoms indicative of a disordered state of the nervous system.

These remote constitutional effects, to which attention has been directed by Hodgkin and James, often do not manifest themselves for weeks or months after the infliction of the injury. Some change appears to be induced in the condition of the blood, or in the action of the nervous system, that is incompatible with health. Perhaps, as Hodgkin supposes, the part locally injured becomes incapable of proper nutritive action, and thus a morbid poison results, in consequence of some peculiar combination of the chemical elements of the part, by which the whole system is influenced. Be this as it may, the fact remains certain, that chronic constitutional disturbance, serious illness, or even sudden death, may supervene, as a result of a local injury, a considerable time after its infliction.

Remote Local Effects.—The possible remote local consequences of severe injuries deserve more attention than they usually receive. There can be no doubt that many structural diseases owe their origin to long antecedent injuries. The nutrition of a part may be modified to such an extent by a blow or wound inflicted upon it, as to occasion those alterations in the structure which constitute true organic disease. Thus we occasionally find, on death occurring many months after a severe injury, that extensive local mischief, usually of an inflammatory character, is disclosed, which has evidently been going on in an insidious manner from the time of the accident.

In other cases again, a blow may give rise to severe and long-continued neuralgic pains in a part; or it may be the direct occasioning cause of structural disease in bones, joints, or blood-vessels; and, lastly, it may be the starting point of cancerous or other tumours, many cases of which can be distinctly referred to external violence.

CHAPTER IX.

INJURIES OF SOFT PARTS.

These consist of *Contusions* and *Wounds*.

CONTUSIONS.

In a **Contusion** the skin is unbroken, but there is always some laceration of the subcutaneous structures. Indeed, great disorganization of these occasionally takes place, though the skin continues entire, owing to its greater elasticity and toughness. Hence a contusion may be looked upon as being a subcutaneous lacerated wound.

In contusions there is always **extravasation** of blood into the tissues to a greater or less degree. When slight, this extravasation is termed an **ecchymosis.** The blood is not shed outwardly, but accumulates under the skin in the areolar tissue, or in internal organs, presenting in the former situation the ordinary purplish-black discoloration of a bruise. The amount of blood extravasated will of course depend upon the vascularity of the part contused. The arrest of the extravasation is due in great measure to the effused blood, pent up amongst the tissues, coagulating over and compressing the torn vessels which have poured it forth; thus restraining the further escape of blood from them, and allowing the ordinary process of repair of wounded vessels to take place.

Causes.—Contusions may result from *direct pressure*, as when a part is forcibly squeezed; from a *direct blow*, usually by a hard blunt body; or from an *indirect blow*, as when the hip-joint is contused by a person falling on his feet from a height.

Compression of the parts injured is always necessary to constitute a contusion. This compression may occur between the force on one side, and a bone as the resisting medium on the other; or the part injured may be compressed and contused between two forces in action—as when the hand is caught between two revolving wheels; or between a force in action and a passive medium—as by a wheel passing over the limb and crushing it against the ground.

Degrees.—The amount of extravasation of blood consequent on a contusion will necessarily depend mainly upon the force employed in its production, but also to some considerable extent upon the state of health of the individual bruised. In persons out of health, with soft tissues, bruising very readily occurs. Contusions are of various degrees: they may be arranged as follows:— 1, **of the Skin only**; 2, with **Extravasation into the Areolar Tissue**; 3, with **Subcutaneous Laceration of the Soft Parts**; and 4, with **Subcutaneous Disorganization of the Soft and Hard Parts.**

In the *first degree*, the blood is effused merely into the skin, producing ecchymosis or bruise; the colour of which varies at different periods from

purplish-red to greenish-brown, this variation being dependent upon changes that take place in the extravasated blood as it undergoes absorption.

In the *second degree* a bag of blood can often be felt fluid and fluctuating under the skin, in which state it may remain for weeks or even months without undergoing any material change, provided it be excluded from the air. In other cases it gradually becomes absorbed; or, if it communicate with the air—the bag being opened in any way—it will undergo putrefaction, unless special antiseptic precautions are taken to prevent it, and will excite inflammation and suppuration around it, the clots being discharged mixed with pus. In some cases it would appear, from the observations of Sir P. Hewett and Sir J. Paget, that the clot resulting from extravasated blood may become organized and finally penetrated by blood-vessels. The French pathologists have described the formation of a cyst containing serous fluid in the site of the extravasated blood. The walls of these cysts are composed of a fibrous tissue; they have no distinct lining membrane, and in their interior serous or grumous fluid, composed of disintegrated blood, is found. Lastly, extravasated blood may give rise to a sanguineous tumour, **Hæmatoma**; the blood, which may continue for months, or even years, fluid, slowly deposits its fibrin upon the tissues amidst which it is lying, thus forming a sort of imperfect cyst well, while the fluid contents become dark and treacly.

In the *third and fourth degrees* of contusion, the laceration and disorganization of structures usually lead to sloughing and suppuration, or to rapid gangrene of the parts, or to hæmorrhage, ending in fatal syncope; or, when the contusion is of an internal organ, this hæmorrhage may prove fatal by taking place into the serous cavities. When the contusion is superficial, the hæmorrhage is subcutaneous, and though abundant, is rarely in sufficient quantity to influence the heart's action. In one remarkable case, however, in which a schoolmaster was convicted of manslaughter for beating a boy to death with a stick, and in which I was called to make a *post mortem* examination, death had evidently resulted, in a great measure at least, from this cause: the subcutaneous areolar tissue of the four limbs being extensively torn away from the fasciæ, and uniformly filled with extravasated blood, whilst the internal organs were in an anæmic condition, even the pulmonary vessels and the coronary arteries of the heart being emptied of blood.

Diagnosis.—This is not always easy. The more severe degrees may be mistaken for incipient gangrene, the discoloration being not very dissimilar, and the resemblance being sometimes increased by the formation of blebs upon the skin containing serous fluid more or less darkly coloured with blood; but the part, when simply contused, preserves its temperature and vitality. In some cases the extravasated blood has a hard circumscribed border of clot, and is soft in the centre, which in the scalp resembles somewhat a depression in the subjacent bone.

The diagnosis of old cases of extravasation, leading to hæmatoma, from abscess or malignant disease, is not always easily made by tactile examination alone; but the history of the case, exploration with a grooved needle, and examination of the contents of the tumour under the microscope, will always clear up any doubt that may exist.

Treatment.—In the first two degrees of contusion, our great object should be to excite, as speedily as possible, the absorption of the extravasated blood. Here cold applications are of especial service; lotions composed of one part of

spirits of wine to eight or ten of water should be constantly applied. Leeches —commonly used in these cases—should not be applied to a bruised part; they cannot remove the blood that has already been extravasated, and often set up irritation, which leads to suppuration. The bag of blood should not be opened, however soft and fluctuating it may feel, so long as there is any chance of its being absorbed. If once it be punctured and unpurified air be allowed to enter, putrefactive suppuration will be set up in it. The fluid blood may, however, in such case be safely removed by means of the aspirator, a large needle being used, and the puncture being closed by collodion. If signs of inflammation occur, the parts becoming red, hot, and painfully throbbing, free incisions should at once be made with antiseptic precautions, the blood—already disorganized and mixed with pus—evacuated, and the cavity allowed to granulate.

In the third and fourth degrees of contusion, it is often useless to attempt to save the life of the injured part; but, if this is attempted, much may be done to prevent the fever and suppuration that sometimes attends the separation of the sloughs. The skin, being in such cases unbroken, must be washed with a solution of carbolic acid (1 in 20), after which an antiseptic dressing may be applied, beneath which the sloughs will separate with scarcely any febrile disturbance, and but little suppuration; the ulcer that results must be treated on general principles.

Disorganizing contusions of the most severe kind may be recovered from *provided there be no external wound*, even though the soft structures of the limb or part be extensively crushed, the bones comminuted, and the joints opened. It is not the subcutaneous lacerations and disorganizations that are to be dreaded; so long as the main blood-vessels of the part injured are intact, these may be recovered from. But it is the admission of air, bearing with it the cause of decomposition, into the interior of a badly injured limb that constitutes the great danger. If this can be avoided there is little fear of undue inflammation being excited; but if impure air be admitted to the lacerated tissues, putrefaction followed by suppuration and sloughing is at once set up, and the safety of the patient will be seriously imperilled. In such cases as these, amputation is usually the sole resource, unless the progress of the mischief can be arrested by the employment of an efficient plan of antiseptic treatment.

The difference between the effects of a subcutaneous laceration and one accompanied by open wound is well exemplified in the cases of a "simple" and a "compound" dislocation. In the first case, although the ligaments and capsular muscles are extensively torn, often with great extravasation of blood, repair takes place without any serious trouble; whilst in a compound dislocation, in which air has been admitted and has given rise to putrefaction of the extravasated blood and the inflammatory exudation, the most extensive suppuration necessarily ensues, and joint, limb, or life, one or other, is in great danger of being irretrievably lost.

Contusions of internal organs are always very serious, and require special treatment, according to the part that is affected, and the extent of its injury.

The blood which has been extravasated in simple subcutaneous contusions sometimes undergoes certain changes—not of a putrefactive character it is true, but still of such a nature as in many cases to render its absorption a

source of constitutional disturbance. Hence it occasionally follows that this absorption of large extravasations is followed by some of the minor evidences of blood poisoning—such as boils, sallowness of skin, low health, and rheumatic pains. These effects are best remedied by sulphurous waters, free purging, alteratives, change of air, &c.

Strangulation of Parts.—This, when accidental, occasionally occurs as the consequence of the application of a constricting ligature or bandage, or the slipping of a tight ring over a part. In such cases, the first effect of the constriction is to prevent the return of the venous blood ; this impediment to the circulation occasions serous effusion, and swelling of an œdematous character. If relief be not afforded to the circulation by the removal of the constricting body, distension of the vessels, stagnation of the blood, loss of vitality of the part, and gangrene will speedily ensue. In many cases in which the strangulation is relieved by the Surgeon, the loss of vitality is far advanced but not complete, and the restoration of the circulation is then followed by inflammation, varying in intensity with the degree of damage that the tissues have suffered. This is, indeed, merely an illustration of the fact experimentally demonstrated by Cohnheim, that arrest of the circulation or exclusion of blood from a rabbit's ear gives rise, when the circulation is restored, to inflammation, the intensity of which can be determined by the duration of the interference with the flow of blood. The most familiar example of this condition in actual practice is the inflammation of the gut that so frequently follows reduction of a strangulated hernia.

The treatment of strangulation consists in at once dividing or removing the cord or ring, as the case may be. Usually this is easily done, but in some cases it is attended with no little difficulty. This happens especially when a small ring has been hurriedly put on a wrong finger, or when the penis has been drawn through a brass ring. In such cases as these the member swells greatly, and the difficulty of removing the foreign body is very considerable. The finger-ring may usually be removed by slipping a director under it, and clipping or filing it across upon this. Sometimes the following popular plan may advantageously be adopted. A strong silk thread is carefully bound round the finger as tightly as possible from the tip down to the ring, under which the free end is carried with a needle : the thread is then slowly untwisted, and the ring is thus carried upon it off the finger. Curtain or other brass rings compressing the root of the penis have been known slowly and gradually to cut through the organ, without destroying its vitality or rendering the urethra impervious ; but such a fortunate result is altogether the exception ; in the great majority of such cases, unless the ring be speedily cut off, mortification of the organ would ensue, and might be followed, as it has been in some instances, by the death of the patient.

Subcutaneous Wounds.—The remarks that have just been made with respect to the effects of the admission of air into extravasations of blood and subcutaneous lacerations or contusions, apply with equal force to subcutaneous wounds ; indeed such lacerations, ruptures, and injuries, are, properly speaking, subcutaneous wounds ; that is to say, bones, muscles, ligaments, tendons, and blood-vessels, may be broken, torn, contused, and ruptured, and yet if the skin covering the parts be unbroken, so that the entrance of air is excluded, complete repair may take place without the inflammation at any time passing beyond the simple traumatic or adhesive stage, and without more than the

slight degree of traumatic fever inseparable from all serious injuries, and which in the slighter injuries would not be recognizable.

The Surgeon takes advantage of this most important fact in many of his operations which are performed *subcutaneously;* that is to say, the narrow blade of a knife is introduced through a puncture in the skin, tissues are freely divided, and on the withdrawal of the knife the wound is so closed either by the approximation of its valvular edges, or by the pressure of a compress, that the entrance of air is prevented, and thus healing takes place by the first intention, without local inflammation or constitutional disturbance, as in a subcutaneous laceration. This is the principle on which all operations of tenotomy and myotomy are performed. Many of the operations on the eye also appear to owe their safety to the same principle being involved in them, the non-entry of the air in these cases being perhaps due rather to the contraction of the eyeball after the escape of its aqueous humour or lens than to any special design of the Surgeon.

The only treatment needed in a subcutaneous wound, whether the result of accident or made by the Surgeon's knife, is Rest and protection of the skin. The unbroken skin is a more certain antiseptic than any surgical dressing.

OPEN WOUNDS.

A wound may best be defined, in the words of Wiseman, as "a solution of continuity in any part of the body, suddenly made by anything that cuts or tears, with a division of the skin."

Surgeons divide wounds into five kinds, **Incised**, **Lacerated**, **Contused**, **Punctured**, and **Poisoned.**

INCISED WOUNDS.

Incised wounds are such as are made by a sharp cutting instrument such as a knife or sword. They may vary in extent from a simple superficial cut to the incision required in amputation at the hip-joint. Incised wounds are usually open, the air having free access to them; occasionally, however, when made by the Surgeon, they are subcutaneous, communicating externally only by a small puncture. They may be simple, implicating merely integument or integument and muscle; or they may be complicated with injury of the larger vessels and nerves, or of important organs.

SYMPTOMS.—In all cases incised wounds give rise to three symptoms; viz., Pain, Hæmorrhage, and Separation of the lips of the wound.

The **Pain** in an incised wound is usually of a cutting, burning, or smarting character. Dr. J. Johnson compared his own sensations to the pain produced by a stream of molten lead falling upon the part. Much depends, however, on the extent and situation of the wound; and also whether the cut has been made from the cutaneous surface inwards, or from within outwards; in the former case the pain is greater than in the latter, because the nerves are divided from the branches towards the trunk; whereas, when the cut is from within outwards, the trunks are divided first, and the terminal branches being thus paralyzed, do not feel the subsequent incision.

The amount of **Hæmorrhage** necessarily depends upon the vascularity of the part as well as on the size of the wound. The proximity of the part wounded to the centre of the circulation, or to a large vessel, has also a very considerable

influence, different parts of the same tissue bleeding with different degrees of facility; thus the skin of the face yields when cut more blood than that of the leg. Again, the same parts will, under different states of irritation, pour out different quantities.

The **Separation of the Lips of the Wound** depends on the tension and the position of the part as well as on the elasticity and vital contractility of the tissues; it is also influenced by the direction of the incision, according as this is parallel with the axis of a limb or muscle or across it. It is greatest in those parts that are naturally the most elastic or that possess the highest degree of tonicity; thus the muscles when cut retract some inches, the arteries and skin gape widely when divided, whereas in the case of ligaments or bones, no retraction takes place.

Management of Incised Wounds.—In the treatment of an incised wound, we must always endeavour to procure union by primary adhesion (p. 269) between a portion, if not the whole, of the surfaces, for reasons already assigned. The probability of procuring adhesion depends greatly upon the constitution of the patient; it is a decided and most dangerous error, and as unscientific as it is dangerous, to suppose that success or failure is entirely dependent on local conditions and the management of the wound itself. In some constitutions it is impossible, under the most favourable circumstances, to obtain it. The sounder the constitution, the more readily will union by the first intention take place; and in all cases it is disposed to by the removal of all sources of irritation from the system, and by the adoption of a supporting regimen. Repair, like all other physiological processes, is attended with an expenditure of vital force directly proportioned to the extent to which plastic material is separated from the blood; hence anything approaching to a lowering plan of treatment is to be avoided, though the opposite error of over-stimulation is equally to be deprecated. Thus, in those operations, the plastic, for instance, in which it is necessary that the union be as direct as possible, the patient should be prepared by being kept for some time previously upon a diet consisting chiefly of milk and light animal food, by taking regular exercise, and by the administration of iron; we should look specially also to the state of the digestive and urinary organs. In cases of accidental wound, we must keep the patient quiet, put him on a moderate diet, and be very cautious in the administration of stimulants, as they have a great tendency to interfere with union by the first intention. It must be borne in mind, that the great object is to limit inflammation; for if this be carried beyond what is necessary for plastic effusion, suppuration will certainly follow.

Homogeneity of structure in the opposed surfaces is favourable to union by first intention, but we must not imagine that union by first intention is not possible between dissimilar tissues; thus muscle may adhere directly to cartilage, or skin and fat to bone. The medium of adhesion, as we have already seen in such cases, is the plastic exudation which forms in the first few hours after the injury, and keeps the opposed surfaces steadily in contact and at rest till the development of the permanent bond of union takes place.

Local Treatment.—Wounds heal, but cannot be said to be cured. Over-zealous attempts at "curing" wounds often lead to the aggravation rather than to the remedying of the original injury, and entail the superaddition upon it of disease which is the direct result of the continued applications of lotions and ointments. There is nothing worse than pottering and meddle-

some Surgery. If the "nimia cura medicinæ" is often the cause of much evil, the Surgical form of the same kind of practice is equally disastrous. A wound left to Nature may heal in a few days; tormented by meddlesome and injudicious Surgery it may remain open for months.

In the treatment of wounds the first four days is the most important period, and the fate of the wound, whether it shall heal by first intention or by the slower process of granulation, is practically determined in the first twenty-four hours. It has already been pointed out in the Chapters on Inflammation and Repair that, as the necessary result of the injury done by the knife, a limited traumatic inflammation is set up, accompanied by abundant exudation of liquor sanguinis and migration of corpuscles; the liquid exudation coagulates, the serum drains away, and the coagulated fibrin with the white corpuscles remains behind, forming the "plastic exudation" which serves as the first bond of union. This process *must* occur, but it should be completed by the first twenty-four hours, at the end of which time the tissues should have recovered from the damage done by the knife, exudation should cease, and the period of traumatic inflammation be at an end. Should any fresh source of irritation be brought to bear on the surfaces of the wound the inflammation will persist, the migration and exudation will continue, and pus will form instead of the desired plastic exudation, and all adhesion between the surfaces is prevented. The sources of irritation against which we have to guard are—first, *mechanical*, viz., the presence of foreign bodies, the tension from accumulation of blood-clot or discharges, and friction of the surfaces against each other; secondly, *chemical*, the products of putrefaction and the persistent action of powerful antiseptics; and thirdly, *specific infective poisons*, erysipelas, hospital gangrene, some forms of pyæmia and septicæmia. It is evident, therefore, that, guided by these principles, the following are the essential features of the treatment of a wound:—1, Arrest hæmorrhage perfectly; 2, Remove all foreign bodies and clean the wound; 3, Bring the surfaces accurately into contact; 4, Provide perfect drainage for the serous discharge which must be poured out during the first twenty-four hours; 5, Maintain perfect rest of the part; 6, Prevent decomposition of any discharge that may form between the surfaces, and while so doing avoid the constant action of an irritating antiseptic in the wound; 7, Guard the patient carefully from the chance of infection from unhealthy or specific inflammations in the wounds of others.

It must be borne in mind that the healthy traumatic inflammation which results from every wound affects a very limited area, and consequently gives rise to such slight local symptoms that it may clinically pass unnoticed, and it has sometimes been ignored; the term "inflammation of a wound" being applied to the process only when it extends more widely so as to cause redness, swelling, heat, and pain easily recognizable by the most superficial observer. Clinically this may be convenient, but pathologically it is inaccurate. The process by which the plastic exudation is formed is an example of simple traumatic inflammation not spreading beyond the area injured: the later process is a spreading inflammation due to various sources of irritation which have been allowed to act on the wound after its infliction.

There is no subject in Surgery which has undergone more frequent modifications than the local treatment of wounds, from the earliest periods of which we have record. The first, and perhaps the instinctive, method of treating a

wound was to close it up at once and to exclude the air by fixing upon its lips a mass of clay, of chewed leaves, or of cow's or camel's dung. The admission of air was further prevented by pouring oil into it, and putrefaction by the use of wine or balsams. At a later period in the history of our art, tents of various kinds were used, and employed up to a very recent period, in order to keep it open and thus to prevent the injurious accumulation in its cavity of discharges, which might there decompose and putrefy. The closure of the wound—the exclusion of air—the prevention of putrefaction in its discharges by the use of spirituous and stimulating antiseptics, or by facilitating the escape of the secretions—were the means employed from the most remote antiquity. That these methods were in many cases highly successful there can be no doubt. They were purely empirical—the outcome of prolonged experience—there being no recognition of those principles involved in the use of the various appliances and medicaments adopted, which it has been reserved for a later and more scientific age to determine and elucidate.

And it is still these four great principles,—the closure of the wound,—the prevention of putrefaction,—the facilitation of the escape of discharges,—and the maintenance of perfect rest between the opposed surfaces, that guide us in the treatment of all wounds, however different, and in some respects improved, the means may be by which we endeavour to carry them out.

In the local treatment, then, of all incised wounds, there are six chief indications, viz., 1, the *Arrest of Hæmorrhage;* 2, the *Removal of Foreign Bodies;* 3, the *Coaptation of the Sides of the Wound;* 4, the *Provision of Perfect Drainage;* 5, the *Maintenance of Perfect Rest;* 6, the *Prevention of Decomposition of the Discharges and Infection of the Wound.* These we shall consider more in detail.

1. **Arrest of Hæmorrhage.**—If bleeding be general from the surface, it may be stopped by exposure to the air, by elevation of the wounded part, by accurate and firm coaptation, by the pressure of a well-applied bandage or of the finger over the spot, and by the use of cold or other styptics; if it be arterial, by ligature, torsion, or acupressure. In making choice of a hæmostatic, preference is to be given to that which will interfere the least with union by the first intention. Thus, among styptics, cold, in the shape of ice or of rags wrung out of cold water, is to be preferred to others of the same class, such as the perchloride of iron, which are all more or less caustic and irritant. Again, torsion should be employed when it can be done with safety, rather than other means; and if the ligature be used, it should be, if possible, of some material which can be absorbed and will not offer any obstacle to the occurrence of union by the first intention.

2. The **Removal of Foreign Bodies**, such as dirt, pieces of stone and glass, spicula of bone, coagulated blood, &c., is best effected by allowing a stream of water, to which some efficient antiseptic as carbolic acid, iodine or chloride of zinc has been added, to fall upon the part from a sponge or irrigator, all rough handling of the wounded tissue being avoided as much as possible. Sharp and angular bits imbedded amongst the tissues should be removed by forceps. Above all, this cleansing of the wound is to be done thoroughly, and once for all; a comparatively insignificant body, if overlooked at this time, may effectually prevent adhesion by setting up suppuration, whilst disturbance of the wound after it has been once closed, destroys the layer of plastic exudation which ought to form the early bond of union.

3. The next and most important indication to fulfil, is the **Coaptation of the Opposed Surfaces** as accurately as possible.

As a general rule, the sides should not be brought together until all hæmorrhage has ceased; if, however, there be but slight oozing, this may be arrested by their approximation, and the pressure thus exercised on the bleeding vessels.

The surfaces should be gently brought together, from behind forwards, so as to thoroughly exclude all air and superfluous moisture from the deeper portions of the wound, the skin-margin being the last to be adjusted; due attention should at the same time be paid to relaxing the parts by position, so that there may be no gaping of the lips nor tension on the sides of the wound. For the purpose of keeping all in position, *sutures*, *plasters*, and *bandages* are employed.

Sutures should never be used unless they are really needed, as they are painful in their introduction, and may be irritating in their presence and troublesome as well as painful in their removal. When they are used, if drainage be not carefully attended to they may favour bagging, by causing superficial union, whilst the deeper parts still gape. A suture is in itself almost unirritating, but can become irritating in two ways—either by being applied too tightly, or by becoming tight in consequence of swelling, and thus causing tension; or by absorbing the products of putrefaction, and thus acting as a chemical irritant. The first condition is common to all forms of suture of whatever material they may be made; the second can be avoided by the use of metallic or other non-absorbent substances. When, therefore, sutures are applied in a case, in which it is expected that decomposition of the discharges will take place, a non-absorbent material must be used. The chief non-absorbent substances used for this purpose are threads of well annealed silver or iron-wire of various degrees of stoutness, silkworm-gut, and horsehair. The two last are especially useful in delicate plastic operations on the face. In cases in which some form of antiseptic treatment is adopted, silk forms the best material for sutures; it should be that known as dentists' or twisted silk, and should not be waxed. It should be well soaked for twenty-four hours before being used in a solution of carbolic acid in water (1 in 20). In some cases fine catgut forms a convenient form of suture, but this cannot be relied upon for more than three days. It has the great advantage of not requiring to be taken out, as the deep part of the stitch becomes absorbed if it is protected from decomposition. The thickness of a suture should vary with the nature and situation of the injury. Thus in wounds of the limbs where much traction may be expected, the suture should be thick; whilst in those cases in which it is of importance that as little deformity as possible should be left, *e.g.*, in plastic operations and in wounds about the face, it should consist of the finest material compatible with the required strength. The threads are introduced by means of needles, either straight or variously curved: in some instances it is convenient to have them set in a handle with the eye near the point (nævus-needle), instead of in the ordinary position. For metallic threads a slight modification of the ordinary needle is required, to prevent the wire when doubled back after passing through the eye from offering any obstruction to its passage through the tissues; "tubular" needles are also employed for this purpose.

The modes of applying sutures are various; but the one most commonly

employed in all cases involving the integument, is the **interrupted**, which consists of the introduction of as many single stitches as may be necessary to close the opening. The distance between the stitches must be determined by the amount of tension, and by the necessities of drainage. If there is even moderate tension, it is better to insert a few sutures, of a thicker material, or "sutures of support," extending deeply into the subcutaneous tissue, the needle being made to pierce the skin an inch or more from the edge of the wound. These sutures are first tightened to such an extent as just to approximate the lips of the wound, which may afterwards be brought more accurately into contact by finer stitches or "sutures of apposition." If ample provision is made for drainage by the use of tubes the edges of the wound may be brought very closely in contact, otherwise in large wounds there should not be less than one inch between the stitches. When, as in some plastic operations, one edge of the wound is at a higher level than the other, if it is desired to depress the higher edge, the stitch must be so passed that it shall include a larger piece of the lower; if to raise the lower edge, the chief hold must be on the higher. In longitudinal wounds, the first stitch should be inserted in the centre; but if there be any angles, as must be the case after crucial incisions, the extremities should be first closed. The fastening is effected in the case of the silk thread by tying the reef-knot, and in that of the wire, by tying a half knot and then crossing the two ends over each other, by which two small hooks are made which hold very firmly; in both instances, the ends are cut off short. The knot or twist must not lie over the line of incision, but on one or other side of it. The time that the sutures should be allowed to remain, must depend greatly on the nature and progress of the wound. A septic silk stitch must be removed in from two to three days; an aseptic silk or a silver suture may be left in as long as it serves any useful purpose, provided it is causing no irritation. A tight stitch necessarily causes irritation; in from twenty-four to forty-eight hours it will be surrounded by a blush of redness extending an inch or more from the edge of the wound, and by the third day it will have commenced to cut its way out by ulceration. When this occurs, no good purpose can be served in most cases by retaining it, and it should be at once removed. All deep stitches should as a rule be removed not later than the third day. In withdrawing sutures, the knot or twist should be raised by forceps, and the thread divided on one side of it; gentle traction on the knot, the forefinger of the other hand being placed close near the point of exit in the skin, to prevent disturbance of the newly formed granulation-tissue, will then suffice to draw the suture out. When wire has been used, the bends in it should be straightened as much as possible before pulling them out.

The **Button-Suture** is a very useful form of deep stitch in cases in which there is considerable gaping of the wound. It consists of a thick piece of silver wire penetrating deeply through the subcutaneous tissue and passing through the skin from one inch and a half to two inches on each side of the wound. Each end of the silver wire is passed through an oval piece of sheet lead about one inch in its long diameter, and perforated with a hole in its centre; on the button are projecting wings round which the wire can be twisted after it has been brought through the hole. The two buttons are drawn together and maintained in position by wire twisted round them, in such a way as to bring the edges in sufficient apposition to allow of the finer

stitches being inserted at the edges of the wound without undue tension. The button diffuses the pressure over the whole area upon which it presses, and thus a considerable degree of traction may be applied without causing ulceration or sloughing. It is especially useful after the excision of malignant tumours with a portion of skin.

In the **continuous suture**, or glover's stitch, the thread is carried on from stitch to stitch, instead of being detached from the needle, and fastened off as in the interrupted suture. The stitches are placed nearer together, so that the adjustment of the edges is more intimate. Either metallic or silk thread can be employed; in withdrawing it, each loop must be divided, and each piece removed separately, as in the common stitch. This form of suture is not very often employed. It is chiefly used in wounds of the intestine.

The **quilled suture** is employed where the sides of a deep longitudinal wound are required to be kept in contact throughout, as in ruptured perinæum. It consists of a series of double interrupted sutures of stout silk, whipcord, or silver wire passed deeply, through the loops of which, that hang out on one side of the wound, is passed a piece of bougie, or quill, whilst the ends of the thread are tightly tied or twisted over a similar cylinder on the opposite side. The stitches should enter and emerge about half an inch from the line of incision, and be so placed that the cylinders when *in situ* lie parallel to one another. Fine interrupted sutures may be used in addition, to connect the superficial parts.

The **twisted** or **figure-of-8 suture** is very commonly employed in surgery. A slender pin, made of soft iron, with a steel point, is introduced through each lip of the wound, at a distance of about one-third of an inch from the margins; and, whilst the latter are held in contact, a piece of silk twist is passed in a figure-of-8 round the pin, care being taken not to draw it too tight, nor to compress the soft parts between the needle and the thread, lest sloughing ensue. The projecting ends of the pin are now cut off with pliers, and the skin beneath them protected with plaster. This suture is used in the treatment of hare-lip; but it is of great service wherever the lips of the wound are very vascular; it has the advantage, likewise, of taking the tension off the suture, so that it is less likely to cut its way out than the interrupted suture. The pin may be withdrawn in about forty-eight hours.

Plasters are of various kinds, those most commonly employed being the resin, soap, and isinglass plasters. Each of them possesses peculiar properties, fitting it for use in particular cases. The resin-plaster has the advantage of being most adhesive, and of not being readily loosened by discharge; but, on the other hand, it is irritating, sticky, difficult to remove, and, in consequence of the lead that it contains, leaves a dirty-looking incrustation behind it. The soap-plaster is less irritating, but at the same time less adhesive; it is consequently not much used in the management of wounds. The isinglass plaster is doubtless the most cleanly and least irritating of all, and, being transparent, permits the Surgeon to see what is taking place beneath it; but it is readily loosened by the discharges, and is apt to run into a cord.

The American rubber-plaster, which adheres with great tenacity without being either wetted or warmed, will be found very convenient in many cases. It will not stick, however, to a wet surface, but if once applied, is not easily loosened by discharges as it is a waterproof material.

Plasters which require heating, must be cut into strips of convenient length

and breadth and are best warmed by being passed through hot water. In the case of an antiseptic dressing, the plaster may be rendered aseptic by being dipped in a basin containing a pint-and-a-half of boiling water to which one ounce of pure carbolic acid has been added, and well stirred so as to ensure complete solution. All superfluous hair having been removed, and the surface well dried, each strip should be laid down evenly between the points of suture, when these have been used, so as to compress and support each side of the wound with equal force; the longer the strip, the firmer will be its hold, and the less likely it will be to become prematurely loose. In removing the plaster, both ends should be raised at the same time towards the wound, and the strip should then be taken off without either lip of the wound being unduly dragged upon. The strips should be allowed to remain undisturbed as long as possible, and each one replaced before the next is removed.

In a certain class of incised wounds, of limited extent, where the edges can be accurately adapted to one another by sutures or plaster, or by the combination of both, and when but little oozing is to be expected, very fair union under a scab may be looked for without any further dressings. The formation of the scab, however, may be hastened and imitated by the use of **Collodion,** painted freely over the line of incision with a camel's hair brush, after the surface has been well dried, or of **Styptic Colloid**, which has the further advantage of being hæmostatic and antiseptic. The film thus formed may be further strengthened by some shreds of charpie or fine lint. A second or third application of the collodion or styptic colloid will be required, if the crust show any sign of becoming detached; otherwise it may be allowed to remain until it separates of itself, which it usually does in the course of a few days. Similarly, a piece of lint soaked in blood, or in compound tincture of benzoin, may be applied over the wound, and under it. Union without suppuration may take place as if under a scab; but the Surgeon must watch for any signs of the formation of matter, as redness of the surrounding skin, heat, throbbing pain, and perhaps fever, and if these appear, the crust must be removed immediately.

4. The *provision for Perfect Drainage.*—The arrangement of the parts should be such that there may be a ready escape for the serous oozing, which must necessarily ensue in all wounds during the first twelve or twenty-four hours after their infliction. This should be allowed to take place from what will be eventually the most dependent point of the wound. In former times when ligatures of compressed whip-cord or waxed silk were used, the threads were all brought out at one spot, and, if thick and numerous, served as a conduit or drain. In the present day, hæmorrhage is almost invariably arrested by torsion or by means of ligatures of carbolized catgut, fine unwaxed silk, or some other material, which if left in the wound, will become absorbed or encapsuled without giving rise to suppuration; consequently, it is necessary in most cases to insert a "*drainage-tube*" (Fig. 99) well into the wound, and retain it there from 48 hours to several days, according to the amount and character of the discharge. The value of the drainage-tube in preventing the accumulation of blood, of bloody serum, and of pus, cannot be over-estimated. It is the greatest safeguard we have against the accumulation of decomposable fluids in the wound, and, more than any other means, favours cohesion of its opposite sides, and secures the patient from all danger of septic contamination. Its use should never be omitted, especially if the wound be deep and irregular,

or if there be danger of bagging under a flap. If a drainage-tube be not used, the stitches must be applied at longer intervals, a wide space being left between each for the exit of discharges. In operations the wound should whenever possible be made in such a direction as to facilitate drainage.

5. The *Maintenance of Perfect Rest.*—One important point in the management of every wound, is to maintain the injured structures, as much as possible, in a state of *rest.* This is to be done by position, the Surgeon refraining from disturbing the parts unnecessarily, using his eye rather than his hand to judge of the progress made, and by the adoption of some mode of dressing that requires to be changed but seldom. In some cases *Compresses* of soft linen or lint may be so disposed as to aid in keeping the sides in apposition, whilst they prevent the collection of fluids in the recesses of the wound; the *bandages* should be applied over them so as to exert a steady well-regulated pressure, but not to impede the free circulation of blood in the part. The elastic pressure of a large mass of cotton-wool as applied in some of the forms of dressing to be described hereafter maintains rest in the highest perfection.

6 and 7. *The prevention of decomposition of the discharges and of infection of the wound* must be carried out by means founded on the principles already laid down when treating of the causes (p. 163), and the prevention of inflammation (p. 191).

METHODS OF TREATING WOUNDS.

It is impossible to give a complete account of all the various methods of treating wounds which the general recognition of the foregoing principles has given rise to. Excellent results have been obtained by different Surgeons by methods apparently differing widely, and circumstances often oblige a Surgeon to adopt one means in preference to another. Some of the most important only will therefore be described here.

Exclusion-of-Air- or Occlusion-Methods.—The complete sealing of a wound by some adhesive and impermeable material after accurately adjusting the edges and surfaces seems so natural a mode of treatment that it is not surprising that it should have been frequently attempted. By this method, admission of air with all its attendant evils is apparently prevented, and it was hoped the wound might follow the course of a subcutaneous injury. All such hopes have, however, proved delusive, as at the same time that the air is excluded all discharges are shut in, and tension and inflammation naturally follow. It is only in the very smallest wounds, such as cut fingers, or the like, that this treatment can possibly be successful; and even then it frequently fails, and many wounds, which might have healed without trouble if properly treated, have been rendered serious by the "bit of sticking plaster" invariably applied if the case is first taken to a chemist's shop. It may be broadly stated that no method of treatment by complete occlusion has ever been successful in large wounds, or can possibly be so.

The Open Treatment of Wounds.—This consists in the application of no dressing of any kind. The edges are approximated in such a way as to allow of perfectly free drainage, and the injured part is placed in such a position as to relieve tension and place it at perfect rest; it is then merely covered by a thin piece of muslin to keep off flies. Beneath it should be placed some waterproof material to catch any discharge that flows away, and

this may be changed whenever necessary. This method of treatment is sometimes followed by very good results. The cleaning of the surfaces, the approximation of the edges, and the drainage are conducted on ordinary principles and require no further notice; but the prevention of decomposition is very imperfectly carried out. If the drainage is perfect, and nothing but healthy plastic exudation remains between the surfaces, no decomposition will take place in the deep part of the wound. If, however, there happen to be a pocket or cavity containing serous fluid, this will certainly decompose, and septic fever and suppuration will follow. Such discharges as flow away, are partly removed by changing the waterproof material beneath the wound, and partly become dry about the edges, and when dry are incapable of decomposition. Thus, with perfect drainage and dry air, a wound treated in this way may run an almost perfectly aseptic course; but such a result is wholly exceptional, and cannot in any way be relied on. Rest is obtained tolerably perfectly, as the disturbance of dressing is almost completely avoided. The prevention of infection is entirely neglected. On the whole it may be said that although this mode of treatment is vastly superior to any attempt at complete occlusion, it is not to be recommended, as in the majority of cases it fails completely in the prevention of decomposition, and consequently leaves the patient exposed to the dangers of septic absorption and of infective inflammations.

The **Simple Water-Dressing** strongly advocated by Liston as a substitute for the older method of poulticing wounds, was a mode of treatment extensively adopted until about twenty years ago. It closely resembles in its principle the open treatment just described; the only difference being, that instead of leaving the wound absolutely exposed, it was covered by a piece of lint moistened with "pure water," in the first instance left open and subsequently covered with oiled silk. This treatment was often attended by the most satisfactory results; by it the wound was kept clean and cool. Inflammation was prevented and the discharges were allowed to drain away. In many cases there was but very little suppuration. I have seen many large wounds, such as those of amputations, or after excision of the breast, heal almost by the first intention, without any suppuration except such as took place along the track of the ligatures. In the pre-antiseptic days the "water-dressing" was undoubtedly the simplest, cleanest, and safest method of treating large incised wounds, and it still is so in all those cases in which antiseptics are not at hand. Since the nature of putrefaction has been fully understood, and the importance of its prevention has been recognised, the simple water-dressing has been practically abandoned for the antiseptic methods.

The **Dry-Lint-Dressing** was used by Syme and many others before the introduction of antiseptic treatment. It consisted of a pad of dry lint placed on each side of the wound, so as gently to press the surfaces together without interfering with the exit of discharge. Over this was placed another piece of lint about three layers thick, and the whole surrounded by a bandage. This was left untouched for from three to four days, by which time it had usually become soaked in the discharges and more or less offensive from decomposition. This mode of treatment secured rest, apposition, and drainage, and perhaps delayed decomposition by drying the discharges to some extent. Very good results were often obtained by it, but suppuration, followed by pyæmia, was no uncommon occurrence.

The **Cotton-Wool-Dressing** was introduced by A. Guérin, of Paris. In

this mode of treatment, the wound having been cleaned and its edges carefully approximated, and if necessary a drainage-tube inserted, the whole part is covered or enclosed in a huge mass of cotton wool, a foot or more in thickness. Over this a bandage is forcibly applied, so as to compress the wool to about half its previous thickness. The dressing is then left undisturbed for a fortnight or three weeks. The temperature is carefully watched during this period, and should there be any considerable rise after the third day the dressing must be removed at once. Severe pain would be another indication for looking at the wound. The principle of the dressing is this ; perfect coaptation of the surfaces and the most absolute rest are obtained by the uniform elastic pressure of the cotton wool ; all discharges escape from between the surfaces and are absorbed by the cotton wool, and then dried and thus prevented from decomposing ; all infection from without is prevented by the filtration of the air should any circulate through the mass of cotton wool. By this mode of treatment admirable results are often obtained, the wound healing rapidly and painlessly, leaving a simple linear cicatrix. The prevention of putrefaction is, however, very uncertain ; if the discharge is small in amount, and becomes completely dried, the case may run an absolutely aseptic course ; more commonly there is a very offensive smell, sometimes that of ordinary putrefaction, sometimes quite peculiar. With this there is some septic fever during the first few days. Guérin's dressing has undergone some modifications, and its principles, as will be seen hereafter, have been adopted in some forms of antiseptic dressing. The substitution of absorbent wool, *i.e.*, cotton wool completely deprived of grease, for common cotton wool, has rendered the drying of the discharge and the consequent prevention of decomposition more perfect, but even with this it is by no means certain.

The **Antiseptic Treatment of Wounds**, as introduced by Lister, has for its object the absolute prevention of decomposition of the discharges by the application to practice of the germ-theory of decomposition. The theory has already been described so fully, that it remains only to show the mode of its application. The practice does not necessitate the use of any special antiseptic agent, or any special material for dressing ; any method of treatment which entirely prevents decomposition, without the constant contact of the antiseptic agent with the raw surface, carries out the principle. When, however, "Lister's treatment," or, as it is often called, "Listerism," is spoken of, it means the special mode of dressing devised by himself, in which carbolic acid is the chief agent employed, and of which the following is a description.

Every accidental wound which has been exposed for some time before it is seen by the Surgeon, will contain, deposited in it from the air, the organisms which cause decomposition. The first step in such a case is therefore to destroy these by washing the surfaces with a strong antiseptic solution. As a rule carbolic-acid-lotion, 1 in 40, answers the purpose perfectly, but if the wound be dirty or have been long exposed, 1 in 20 may be used. If the injury be a simple incised wound with smooth surfaces, this may be done with a sponge or by simple irrigation ; if it be irregular, as in a compound fracture, it is best carried out by means of a syringe with a piece of soft India-rubber tubing on its nozzle. The tubing is stiff enough to penetrate any existing cavity, but not so stiff as to force a way for itself. Care must be taken in injecting the wound, not to squeeze the lips together so as to get up high pressure in its cavity, for the lymph-spaces in the neighbourhood may become

injected with the solution of carbolic acid, and unpleasant inflammation may follow. The whole of the parts which will be covered by the dressing should be well washed with the 1 in 20 solution. If the wound be on the hand or foot, great care must be taken to clean the nails and between the digits. If on the head or any other hairy part, the hair must be cut, and it is safer to oil what remains with carbolized oil, 1 part of carbolic acid to 9 of olive oil.

In the case of an operation, the skin is first cleansed with the 1 in 20 solution for six or eight inches around the seat of the intended incision when this is possible; it is a good plan to wrap the part in a towel moistened with the 1 in 40 solution for half an hour or more before the operation. This being done, it is necessary to prevent the entrance of organisms to the wound during the operation. They can be carried into the wound in various ways. First, *by the Surgeon's hands;* to prevent this the operator and his assistants must first carefully wash in soap and water, and afterwards dip their hands in the 1 in 40 solution; and the dipping must be repeated whenever the hands have been exposed to the air unprotected by the lotion. Secondly, *by the instruments;* all the instruments must therefore be placed in a bath of carbolic acid and water, 1 in 40, taken out only when wanted, and immediately replaced when done with, if they are likely to be used again during the operation. Thirdly, *by the sponges;* these must be prepared as before described (page 37), and must be freshly squeezed out of the 1 in 40 solution when handed to the assistant. Fourthly, *by the ligatures;* these must therefore be composed either of carbolized catgut or unwaxed silk soaked in carbolic-acid-lotion (1 in 20) for some hours before they are used; or the hæmorrhage may be arrested by torsion, and the use of ligatures entirely avoided. Fifthly, *by the air;* to prevent this, Lister devised the plan of operating under a spray. The use of the spray has already been described under the antiseptic treatment of abscesses (page 246). The spray is the part of Lister's treatment which has met with the greatest amount of opposition. The careful disinfection of the Surgeon's hands and instruments, and of sponges, the cleaning of the patient's skin, and the washing of the wound with solutions of chemical antiseptics, are almost universally practised, and their utility is generally acknowledged; but a large number of Surgeons do not employ the spray. The advocates of the spray urge the following points in its favour: it is the most perfect and continuous mode of irrigating a wound; if the spray be sufficiently fine, it is impossible for any organisms floating in the air to escape contact with one of the minute drops of the antiseptic solution, and thus to be rendered innocuous; consequently, air mixed with spray may be admitted with impunity to the natural cavities of the body, to the deep parts of irregular wounds, and into other situations in which perfect irrigation by any other means would be impossible or dangerous. Lastly, that by means of the steam-spray the Surgeon can examine the wound while dressing it at his leisure, and still maintain perfect irrigation. In confirmation of these views, it may be stated that at University College Hospital, aseptic results have been obtained with much greater certainty since the efficient steam-spray was introduced than while hand-instruments were employed, and that the results of those cases in which the spray has been used have been more uniformly aseptic than when it has been replaced by washing out the wound or by irrigation. The opponents of the spray urge that it is inconvenient during the operation, wetting the Surgeon and obscuring his view; and sometimes, in long operations, giving him

unpleasant symptoms of carbolic-acid-poisoning, such as a general sense of illness, pain in the back, or even hæmaturia; that it may depress the patient and add to shock by chilling the surface; that the spray-apparatus is costly, difficult to keep in order, and inconveniently cumbersome to carry about in private practice; and lastly, the amount of success that attends the antiseptic treatment of accidental wounds is sufficient evidence that good results may be obtained without it. The truth probably lies between the two extremes. The spray is no doubt not necessary in all ordinary cases; Lister himself holds it to be the least essential part of his treatment. In all cases in which cavities are opened, it is a great additional security, especially if the cavity is one in which putrescible matter is likely to accumulate, and which it is impossible thoroughly to cleanse or drain; thus it is of great use in small openings into the pleura, abdomen, or joints. In operations such as ovariotomy, in which the cavity of the peritoneum can be thoroughly cleansed before the wound is closed, and in which the amount of exudation afterwards will not be more than is rapidly absorbed by the serous membrane, experience shows that its use is not essential, although it may give additional security. In an ordinary operation-wound it gives increased certainty of an aseptic result, but with great care and attention to detail in irrigation and in the use of a "guard" during dressing, as described in the treatment of abscesses (page 247), very good results may be obtained. If the spray be used, the obstruction to the view of the wound can be avoided by not putting the apparatus too near; and the chilling of the patient must be prevented by covering the parts not necessarily exposed with blankets and waterproof sheeting.

In cases in which the operation-wound is complicated by the presence of old **sinuses**, such as are met with in many cases of joint-disease, these must be scraped out with a sharp spoon, and afterwards sponged with a solution of chloride of zinc (40 grains to 1 ounce). If the sinuses be numerous it is, perhaps, safer to wash the whole wound out with chloride of zinc lotion, the good effects of which were pointed out by Campbell De Morgan many years ago. Sinuses should not be injected before the operation, as there is some danger of rupturing their walls, and if the chloride of zinc lotion should thus become injected into the cellular tissue, the most extensive and dangerous sloughing may result. In all cases of wound, whether resulting from accident or operation, drainage forms an essential part of the antiseptic system of treatment. The irritation of the antiseptic, applied to the raw surface, increases considerably the flow of the natural serous discharge during the first twenty-four or thirty-six hours. There are no ligatures to form a drain for it, and the edges of the wound are rather firmly pressed together by the dressing. It is necessary, therefore, to provide for the exit of the discharge by means of drainage-tubes. These tubes are prepared and inserted in the same way as in the antiseptic treatment of abscesses (pages 244, 245). One or more must be inserted to the very bottom of the wound, and the edges of the skin may then be brought together as closely as possible, a continuous suture even being used if the Surgeon prefer it. The tubes must vary in size and number with the extent and nature of the wound, and must be brought to the surface at the most convenient and dependent parts. The drainage-tubes should not be moved for the first two days, by which time they will have formed a track for themselves, and can be readily re-introduced if necessary. Sometimes they

can be completely removed on the third day; but usually it is safer merely to shorten them by cutting off a piece at each dressing, till they become reduced to about half an inch in length.

In very small wounds a few strands of catgut or horse-hair will be found to make a very efficient drain.

An essential part of the Antiseptic Treatment of Wounds as devised by Lister, is *the protection of the raw surfaces and edges of the wound as far as possible from any direct contact with the carbolic acid in the dressings*, which would infalliby cause sufficient irritation to produce suppuration. The small quantity of carbolic acid left in the wound when it is closed, is so temporary in its action as scarcely to require consideration. It is partly washed away by the serous discharge and partly absorbed, so that probably in a few hours, or perhaps less, the deep parts of the wound are free from any trace of the acid. To protect the raw surface, the wound is covered with the so-called "protective" (page 246), which being in itself perfectly unirritating, and almost impervious to carbolic acid—as soon as the small quantity of the acid adhering to its under surface has been absorbed by the skin or granulations beneath—almost absolutely protect the wound from any direct action of the irritating antiseptic. The dressing is then applied in exactly the same way as in the treatment of abscesses (see page 247). The dressing must be repeated at first every day, till the serous discharge has ceased, and then every second, third, or fourth day, according to the amount of discharge. If it be thought necessary to apply strapping to the wound, it may be done under the spray, by dipping the plaster in a lotion of one part of carbolic acid and water (1 to 20), to which is added an equal quantity of boiling water. Although attention to detail is of great importance, and in description the dressing may seem complicated and tedious, its application to a wound such as that of an amputation, does not take more than five minutes; and it is not more troublesome than the ordinary modes of treatment. In the rigid antiseptic dressing by Lister's method, drainage is specially attended to on ordinary principles; rest is favoured by the slight rigidity of the eight layers of gauze, by the gentle pressure of the bandage, and by the infrequency of the dressings; and decomposition and infection from without are absolutely prevented.

Modified Methods of Antiseptic Treatment.—The chief modifications of Lister's method of dressing consist firstly, in abandoning the spray, all other details remaining unchanged, and secondly, in the substitution of some other absorbent antiseptic material for the carbolic gauze. The substitution of irrigation or washing for the spray has already been sufficiently alluded to. The chief materials which have been substituted for the carbolic-acid-gauze in the dressing are the following.

Eucalyptic gauze (page 195). This is used in the same way as the carbolic gauze, and has been found to be equally efficient. It is unirritating and non-poisonous, and should always be preferred in children and in patients who are readily affected, generally or locally, by carbolic acid. The chief objection to it is that it is slightly more expensive.

Salicylic cotton-wool or jute is applied in the same way as Guérin's cotton-wool-dressing and is most useful, though uncertain in its antiseptic properties when compared with carbolic or eucalyptic gauze.

Salicylic silk was introduced by McGill of Leeds, who reports very favourably of it. He recommends the employment of the spray of carbolic acid and all

other precautions of Lister's method, merely substituting the silk for the gauze. The dressing is left on for a week or more.

Iodoform wool (page 195) may be applied in the same way as the salicylic wool. It is more powerful and certain as an antiseptic but rather expensive. For the sake of economy the dressing may be made of a layer of iodoform wool about one inch thick covered by two inches of salicylic wool or jute.

Carded oakum, tenax, or marine lint is a cheap and powerful antiseptic, but it is not adapted for direct application to a wound, as it is too irritating. It may, however, be applied superficially over a few layers of gauze as a matter of economy, and used in this way is very efficient. It should be covered with oiled silk or "hat lining" to prevent the discharge from soaking through opposite to the wound and decomposing.

Lint soaked in *carbolic oil* (1 in 10) may be applied so as to extend for some inches round the wound in every direction if the above-mentioned materials are not at hand. It is apt to stick and become dry, and must be changed at least twice a day. In all the above modes of dressing, the "protective" should be applied to the wound, as it prevents the absorbent material from sticking, and thus facilitates drainage and saves pain during the after-dressing. Under all these dressings the wound may, with care, be kept perfectly free from decomposition. The wool-dressings present the advantage of maintaining more perfect rest and apposition of the surfaces.

Lasting Dressings.—During the last few years it has been the object of many surgeons to invent some form of dressing which can safely be applied immediately after the infliction of the wound and not removed till healing is complete. This object has been more or less perfectly attained by some of the methods already described. The simple cotton-wool fails in many cases from decomposition taking place beneath it. The carbolic-gauze-dressing becomes early soaked in discharge and must always, except in very small wounds, be changed at the end of twenty-four hours. Moreover, all dressings in which the common drainage-tubes are employed must be changed now and then to shorten or remove the tubes. To avoid this Neuber invented absorbable drainage-tubes composed of decalcified bone. These are made of various lengths and sizes to fit all wounds. They act perfectly well in most cases, but occasionally they are slow in being absorbed and excite suppuration. After they have been inserted the wound may be covered with a few layers of gauze and over this again a large mass of one of the absorbent antiseptic dressings. In all forms of lasting dressing the temperature must be observed morning and evening, and any rise above 101° or 102° F. after the third day would be an indication for looking at the wound. Pain is a similar indication, as a healthy wound is absolutely painless.

The foregoing are the most important forms of antiseptic dressing in which permanent contact of the antiseptic with the raw surfaces is avoided. The Surgeon need not confine himself to one form throughout each case. A very convenient modification will be found to be the application of one gauze-dressing to be removed at the end of twenty-four hours, after which one of the antiseptic wool-dressings may be applied. By this means the early serous discharge is got rid of which usually soaks the wool-dressings to such an extent as to incur great risk of decomposition.

Irrigation of wounds with an antiseptic solution is sometimes adopted, but it is troublesome, and presents no advantages over the methods already

described, except in the case of foul wounds requiring to be cleaned. The best solution under these circumstances is a concentrated solution of boracic acid.

Iodoform-Treatment.—This has been largely adopted in Germany for the last few years, especially by Billroth in Vienna. It is thus carried out. After bleeding has been completely arrested by torsion or catgut-ligatures, and the wound cleaned, the raw surfaces are freely powdered with the crystalline iodoform and then brought together, drainage-tubes being inserted and the whole covered with iodoform-wool. The results of this treatment have been on the whole good, although many cases of iodoform-poisoning have occurred; but there seems no reason to justify the introduction of the iodoform, which can be regarded only as a foreign body, between the surfaces of the wound. In open wounds with loss of substance which cannot be treated by rigid antiseptic methods, however, such as those resulting from operations on the anus or rectum, or from excision of the tongue or jaw, the direct application of iodoform to the raw surface is of the greatest possible use, and is the best mode of treatment at present known.

In conclusion, some forms of dressing may briefly be mentioned, which, in the hands of certain Surgeons have met with much success. Bryant, of Guy's Hospital, recommends the use of a weak solution of tincture of iodine (ʒij to oj) for washing the wounds, and sponges; and as a dressing he applies lint soaked in a mixture of one part of terebene to five of olive oil (p. 194). This is undoubtedly a most simple and efficient dressing, but it is less certain as an antiseptic where there is much discharge than some of those already described. Hutchinson, of the London Hospital, recommends the application of a piece of lint constantly moistened in the following solution: Liquor plumbi ℥ss., Sp. Rect. ʒj, Aq. Oj. This treatment was much employed in former times, and is attended by excellent results. The solution is powerfully antiseptic, and it is cooling and grateful to the patient. It requires, however, constant attention to prevent the lint from drying, and in this respect is somewhat troublesome, especially in private practice. The methods of treating amputation-wounds recommended by Callender and Bowland are mentioned in pages 68 and 79.

The methods of treatment here recommended are all of established utility, but numberless others have been tried and abandoned, or are at present being tested; and probably we have not yet discovered either the best antiseptic or the best mode of dressing. The tendency of the present time is in favour of some of the forms of lasting dressing, especially the absorbent wools, impregnated with some antiseptic, such as iodoform or salicylic acid.

I cannot too strongly impress upon the young Surgeon the importance of not becoming the slave of any one system of treating wounds. He should be eclectic in the choice of his methods, using that one which appears to be best suited to the particular case before him, or that may alone be available in the position in which he happens to be placed. A Surgeon may find it necessary to take the most stringent antiseptic precautions when treating a wounded patient in the contaminated air of a large hospital in a crowded town. He may safely relax them in the purer air of a healthy country district. He may find it necessary when restricted to the limited resources of an emigrant ship or of a remote colony to learn to dispense with those more complicated chemical and surgical appliances which are to be found in all well appointed Hospitals, and which are essential to the success of many modern methods of

treatment. Let him, by all means, use them when he can get them—but let him remember that wounds were healed safely, speedily and well before they were invented, and that he is the best Surgeon who can obtain the best results by the simplest means. If he is not in the land of spray-producers, "protectives," and "guards," of iodoform- and salicylic-acid-wools, let him not despair—cold water and clean linen rags will do much to supply their place.

Inflammation of Incised Wounds.—As before pointed out, a certain degree of inflammation is a necessary part of the healing of a wound by first intention. This should, however, be strictly limited to the tissues actually injured by the instrument which produced the wound, and should be very temporary in character. This simple traumatic inflammation, although pathologically of such great importance, is clinically so slightly marked by symptoms that it is frequently ignored; and when we say that a wound is "inflamed," we mean that some cause of inflammation other than the original injury has been introduced, which is causing the process to extend beyond the area actually injured by the cutting instrument. The causes of such inflammation have already been so fully discussed that we need do no more here than recapitulate them. They are predisposing and direct. The predisposing causes are the same as those of inflammation in general (see page 159). The most important of these for wounds are: chronic alcoholism, insufficient and improper food, Bright's disease and diabetes, scurvy, &c., and local malnutrition from disease of the arteries. The direct causes are mechanical, as friction from want of rest, tension from tight stitches or from insufficient drainage, or pressure from tight bandaging; chemical, as the persistent contact with the raw surface of an irritating antiseptic or the products of putrefaction; and lastly, the true infective poisons, as those of erysipelas, pyæmia, hospital gangrene, &c. In the vast majority of cases in which a wound "inflames," the immediate cause is the presence of putrid discharges with insufficient drainage.

When a wound becomes "inflamed," the natural slight swelling and redness of the lips becomes exaggerated and extends further from the edges than it should, and instead of tending to subside after the first twenty-four hours, it continues to extend to the third day or even later. The serous discharge, instead of ceasing on the second day, continues to flow and may increase considerably in quantity, and gradually by the third or fourth day assumes a distinctly puriform character. Instead of the perfect painlessness of a healthy wound, there is throbbing tensive pain with acute tenderness. The temperature rises to 101°—104° Fahr. according to the size of the wound and the cause of the inflammation. In all cases the thermometer gives timely warning of the approach of this traumatic fever. The use of this instrument in surgical practice is attended with great advantage, as it is often the first to indicate the onset of some of the more serious sequelæ of wounds. The other symptoms of fever, hot skin, quick pulse, thirst, &c., are also present. In these circumstances all chance of union by the first intention is of course at an end; some or all of the sutures should be immediately removed to facilitate drainage and relieve tension, and strips of plaster may be used for support only and not for the purpose of maintaining contact of the surfaces in the hope of obtaining union. If the wound is aseptic, the relief of tension alone may suffice to relieve the symptoms; if the discharges are decomposing, some warm moist and antiseptic application should be used. The best of these is boracic-acid-lint,

three or four layers thick, moistened in a solution of boracic acid, and applied as hot as the patient can bear it. It must be covered with oiled silk and cotton-wool, and changed every four hours. If this be not available, a small quantity of carbolic acid (about 1 to 50) may be added to the warm water, and applied on lint; or a hot solution containing two grains of chloride of zinc to the ounce may be used. Simple warm-water-dressings and poultices should be avoided, as they tend so powerfully to encourage putrefaction. If the discharge is very abundant, the actual wound may be protected with a piece of lint dipped in carbolic oil (1 in 10), and the whole part surrounded with a mass of oakum wrung out of hot water, and applied like a hot fomentation. If the wound be at all foul, the cavity must be syringed out at each dressing with some antiseptic solution, or a small quantity of iodoform may be powdered into it.

When the signs of acute inflammation have subsided, strips of lint dipped in the lead lotion (p. 313), and applied like straps to bring the surfaces together, will be found a very useful dressing. When granulations have sprung up and suppuration has fairly set in—that is to say, by about the tenth day—the granulating surfaces may if possible be brought together again by plasters and bandages, with a view to their uniting by "secondary adhesion." If this should be impossible, the raw surface becomes a "healthy granulating sore," and must be treated in accordance with the principles that guide us in the management of ulcerated surfaces (p. 259, *et seq.*). During the period of suppuration, the patient's strength must be well supported by proper diet, and his general health carefully attended to.

Inflammation may occur at a later period of the case, owing to a failure in the drainage, and the accumulation of septic matter in the cavity, or to the infection of the wound with one of the specific infective processes, as hospital gangrene, erysipelas, wound diphtheria, &c. Under these circumstances any union that may have taken place breaks down. The symptoms and treatment of the specific inflammation will be fully described in the chapter specially devoted to them. Inflammation from accumulation of decomposing discharges must be treated by partially opening up the wound and re-inserting the drainage-tubes.

CONTUSED AND LACERATED WOUNDS.

These may be defined as wounds that are attended by more or less bruising or tearing about the edges and sides; presenting every possible variety in the degree of contusion and of wound, from a cut on the shin to the crushing and laceration of a limb by a cannon-shot. They are commonly inflicted by blunt instruments, as by stones, bludgeons, &c. Lacerations by machinery, in which parts are torn-off or crushed, the bites and gorings of animals, and gun-shot injuries of all kinds, come under this denomination.

Characters.—Whatever their mode of infliction, these wounds present certain characters in common, by which they differ from all other injuries. Their lips are irregular and torn, less gaping than incised wounds, but surrounded by more or less ecchymosis and contusion. There is usually but little hæmorrhage, and the pain is of an aching or dull character.

They differ from incised wounds in the fact that a distinct layer of tissue injured by the instrument which inflicted the wound is actually killed, and, if of any thickness, must be separated and thrown off, as a slough, before union can take place. No sharp line can, however, be drawn between the different kinds of wounds. Some wounds, which from their mode of infliction and

appearance would be classed as lacerated, are in reality capable of uniting by first intention, the layer of dead tissue being either microscopic or wanting. This is especially the case in vascular parts, such as the scalp and face. In other cases, a wound apparently similar may slough for a considerable distance on each side.

In consequence of the sloughy state of their lips and sides, *the majority of contused and lacerated wounds unite by the second intention.*

Contused and lacerated wounds present peculiarities according to the mode of their infliction.

When they are occasioned by the bite of a large animal, the part injured becomes very painful, and inflames extensively; the wound being lacerated, much contused, and often penetrating deeply. It sloughs in consequence of the pressure to which it has been subjected, and of the shaking and tearing of the part by the animal. When inflicted by the tusk or horn of an animal, the wound is extensively lacerated rather than contused, and often partakes of the nature of a punctured wound.

When a part of the body is torn off, the wound presents peculiar characters; which differ, however, according as the separation is effected at the part struck or seized, or at a distance from it. In the first case—as when a cannon-ball carries off a limb, or an arm is caught in a steam-mill or rag-tearing machine and crushed or torn off—the stump presents a very ragged surface, the skin being stripped away higher than the other parts, the tendons hanging out, and the bellies of the muscles that are torn across being swollen, protruding, and apparently constricted by the lacerated integument. A most important condition in such wounds is the state of the vessels; these are separated lower down than the other parts, for, being elastic, they elongate and pull out before they give way. There is no hæmorrhage, because the inner and middle coats of the artery, breaking off short, retract and contract to a small aperture, and allow the external coat to be dragged down and twisted over them, in such a way as to offer a complete barrier to the escape of blood. The bone is crushed off at the end of the conical stump, of which it forms the irregular apex, and is often split up to the next joint above.

Occasionally, when parts are pulled off, they are separated at a distance from the point seized. Thus, fingers that have been torn off by machinery have their extensor and flexor tendons separated higher up, at their junction with the belly of the muscle, and not at the part seized; the tendon being drawn out of its sheath, and hanging on to the separated end in a ribbon-like manner.

This peculiar tearing away of the tendon from its attachment to the muscle and not across the line of laceration of the limb, was described by several writers in the Memoirs of the Academy of Surgery of Paris in the middle of the last century and the accompanying figures 103, 104, taken from Morand's Paper, illustrate well this very singular injury. In railway accidents, when a train has passed over a limb without completely separating it, the muscles may be found detached from their origins.

Progress.—In the progress of a contused or lacerated wound there are two distinct periods: 1, that of the separation of the slough produced by the contusion; 2, that of Repair by Granulations of the chasm left. These processes are analogous to those which occur in ulceration, described at page 162.

The **Extent of the Slough** depends not only upon the extent and severity,

but also upon the situation of the injury. If the parts around the wound be much bruised, superficial sloughing to a great extent may occur; if the wound be deep though not extensive, there will always be danger of deep suppuration and burrowing of matter, leading to troublesome sloughing, and in some cases to secondary hæmorrhage. Those wounds that are situated immediately over bony points—as the shin and elbow—are especially tedious, as the slough frequently implicates the fasciæ, and therefore separates slowly. The scalp has a less tendency to slough than any other part of the cutaneous surface. This is owing to its great vascularity, and to the large supply of blood which it receives from closely subjacent arteries. In all cases of contused and lacerated wounds, in which sloughing and suppuration follow the

Fig. 103.—Ring Finger torn off, with deep Flexor Tendon.

Fig. 104.—Thumb torn off, with Tendon attached.

injury, there is a greater liability to the supervention of erysipelas than in cleanly cut incised wounds. In most contused wounds the extent of the slough is, to a certain extent, influenced by treatment. On each side of the wound, beyond the layer of tissue actually killed is an area, frequently of considerable extent, in which the tissues are damaged and hovering between life and death, and any additional irritation will suffice to extinguish the remains of vitality. Thus, if such a wound be tightly sewn up the tension of the stitches will inevitably cause sloughing in the whole doubtful area. The irritation of decomposing discharges is another most potent cause of extension of the area of death, and in fact, it is in such wounds much more than in clean cut incisions, that the immense benefit of some form of antiseptic treatment is most clearly recognized. In primary amputations for contused

and lacerated wounds it frequently happens that the incisions pass through this doubtful area, and the extra injury thus done determines the death of the part, even though, at the time, it may have appeared uninjured.

The chief danger to be apprehended in wounds of this description is the supervention of **Gangrene**, which may occur in three ways.

1. In some cases the violence done to the part is so great as directly to kill its whole substance. Thus, if a limb be crushed to a pulp by machinery, or by the passage of a heavy waggon over it, all circulation is completely and at once arrested, the vitality of the part is destroyed outright, and it will speedily fall into a state of putrefactive decomposition, with all the usual signs of mortification. This is a local traumatic mortification, evincing no disposition to spread beyond the part injured, but being bounded by a line of demarcation along which it will separate. It is not always easy to distinguish this direct form of gangrene from such discoloration and disorganization of a limb as are still compatible with life. In all cases of doubt the Surgeon must wait, and a very short time—a few hours—will be sufficient to declare whether the vitality of the part can be maintained or not. In cases of much doubt an incision might be made into the part, and the true state of things thus ascertained: but this should not be done if it can possibly be avoided, and if undertaken the most rigid antiseptic treatment should be adopted, as the decomposition of the extravasated blood in the tissues of the bruised part would inevitably extinguish such vitality as remained. In many cases it is a good plan to disinfect the part carefully, dress it antiseptically, and wait for the line of demarcation between the dead and living parts to form before undertaking any operation.

2. The injury may be inflicted chiefly upon the great vessels of the limb, damaging them to such an extent as to completely interrupt the circulation; gangrene being thus induced indirectly in the parts supplied by them. This form of gangrene we shall have occasion to treat of fully when speaking of Injuries of the Arteries.

3. The true "spreading gangrene," the most fatal variety of mortification, is most commonly the result of severe contused and lacerated wounds, particularly when complicated with fractures. This is a most acute infective inflammation, terminating rapidly in gangrene, and will be described with the other infective processes occurring in wounds.

Treatment of Contused and Lacerated Wounds.—In the treatment of the slighter form of these injuries, we must bear in mind the occurrence of the two distinct periods: 1, that of sloughing; and 2, that of granulation. There is also in all injuries of this description a special tendency to the occurrence of erysipelas and allied diseases.

Care must be taken to clean the parts thoroughly from foreign bodies that are frequently impacted or ground into them. However contused and torn a flap of skin may be, it should, as a general rule, never be removed, provided it maintain any attachment to the neighbouring tissues, but should always be replaced on the chance of its vitality being preserved. If it live, as it will often do, especially about the scalp and face, under apparently the most discouraging circumstances, much will be gained; if it slough, no harm can result from the attempt to preserve it. There are cases on record in which parts that have been even completely separated have become attached, by being immediately reapplied to the surface from which they had been torn or cut.

Whether or not this be actually the case in contused or lacerated wounds, it is at all events certain that a very small tongue of skin is sufficient to maintain the vitality of a part. This we see exemplified in the operation for the restoration of a lost nose; and cases have occurred to me in which the nose, nearly cut off, being retained only by a portion of one ala, has readily united on being replaced; so likewise, in bad cases of compound dislocation of the fingers, the part has been saved, though merely attached by a narrow bridge of skin. After a part has been replaced in this way, it should be retained *in situ* by a few points of interrupted suture, and dressed with boracic acid ointment spread on thin muslin or some other unirritating antiseptic application. In lacerated wounds opening into the mouth or nose a piece of lint soaked in collodion may be applied externally, as there will be ample drainage from the internal aspect of the wound. The sutures in these cases must be left in for a somewhat longer time than usual, until good union has resulted. The hæmorrhage, as before mentioned, is as a rule easily controlled; position, application of cold, and the subsequent bandaging being sufficient in the majority of cases. When, however, the blood is bright-coloured and continues to drip from the wound, a vessel of some size has been divided: this should be searched for, and the opening closed by torsion or ligature.

Ordinary cases of contused or lacerated wounds, whether superficially extensive or deep, are best treated on exactly the same principles as incised wounds. Although we cannot hope for union by the first intention, *rest* is necessary to favour such union as may occur, and to relieve the patient from pain; *drainage* requires special attention, as the injury being more severe, the early exudation from the wound will be more abundant; and the *prevention of decomposition* becomes of the greatest importance, as the irritation of putrid matter might extinguish the vitality in tissues which would otherwise have recovered. In treating such wounds by the antiseptic method exactly the same proceedings must be adopted as in an accidental incised wound (page 308), but greater care is necessary in cleaning the wound with the carbolic lotion on account of its irregular nature. If there is no chance of union at any part, it is better not to insert stitches; for, as it must heal by granulation after the separation of the sloughs, nothing can be gained by their use, and they may seriously impede the drainage. There is no class of wounds in which the benefits of antiseptic treatment are more marked than in these. Under its use the sloughs may separate with scarcely any suppuration, and the inflammation accompanying the process may not extend a tenth of an inch beyond the dead tissue; and all this may occur without any general febrile disturbance. In contused and lacerated wounds of the hand or foot, in which the parts are often extremely dirty, it is safer to put the limb in a bath of carbolic-acid-lotion (1 in 40) for about a quarter of an hour before applying the dressing in order to ensure thorough asepticity.

Should the antiseptic dressing fail, or should the case not be seen till decomposition has commenced, *Disinfectants* must be freely used. The wounds must be washed or syringed out several times a day with weak solutions of chloride of zinc, of permanganate of potash, or of carbolic acid. In this way sloughs and decomposing pus may be removed, and the tendency to local inflammation of a spreading character, and to the development of pyæmia, averted. There is no more fertile cause of these disastrous effects than the retention of fœtid decomposing pus in the areolar tissue of a contused wound.

The separation of the sloughs must be facilitated by the application of warmth and moisture, which serves also to subdue local inflammation. Boracic-acid-lint, moistened with hot boracic lotion and covered with oiled silk and cotton-wool, is the best of all applications. It is a most efficient antiseptic, easily applied, and perfectly clean. If the wound becomes very foul, the surface may be sprinkled with iodoform in crystals. Carded oakum, moistened in hot water and covered with oiled silk, answers the purpose tolerably well ; it is cheap and antiseptic, but dirties the skin. Linseed meal poultices should always be avoided ; they encourage putrefaction and greatly increase the suppuration, the evil they do in this way more than counterbalancing the comfort the patient experiences from their application.

About the period at which the slough begins to be loosened, there is danger of the occurrence of **hæmorrhage**, if a large artery have been implicated in the injury. When hæmorrhage occurs in this way, it usually sets in from the sixth to the twelfth day, and may be speedily fatal ; its treatment will be the same as that to be hereafter described for secondary hæmorrhage after ligature of an artery in its continuity. After the sloughs have separated, an ulcer is left, which must be treated on general principles.

Amputation.—In the more severe cases of contused or lacerated wounds, any attempt at saving the part may be hopeless ; then the patient's only chance lies in *amputation.* In determining the expediency of operation, two questions present themselves : 1, the nature of the cases in which amputation should be performed ; and, 2, the time at which it should be done, whether immediately after the infliction of the injury, or subsequently.

It is difficult to lay down more than very general rules as to the *kind of cases that require amputation ;* much depending on the age, constitution, and previous habits of the patient. In all cases the Surgeon should be careful not to condemn a limb that admits of a fair chance of being saved.

As a general rule, severe injuries are more readily recovered from in the young than in the old, their vitality and elasticity of constitution being greater, and their tendency to consecutive diseases less. Much will depend upon the habits of the patient, or upon the existence of visceral disease at the time of the injury. In persons who have been free livers, and who have that peculiar irritability of system conjoined with deficient power commonly observed in such subjects, and more especially if there be already existing disease of the liver or kidneys, contused and lacerated wounds are apt to be followed by the worst forms of erysipelas and traumatic gangrene, and thus to be speedily fatal. Injuries of the upper extremity are less serious than those of the lower ; its supply of blood being proportionately greater. In some badly contused wounds, also, of the arm and hand, as in bad lacerations with fracture about the shoulder, elbow, or metacarpus, resection of the injured part may be performed instead of amputation of the limb.

Though there must be in many cases a doubt as to the necessity of amputation, there are certain conditions in which the Surgeon need never hesitate to perform this operation, as the only chance of saving the patient's life. The following are the cases of severe contusion and laceration in which the limb should be amputated ; either with the view of preventing the occurrence of gangrene, or in order to remove a mortified part from the body, and thus to save the life of the patient at the expense of the injured limb.

1. If a limb have been torn off by machinery, carried away by a cannon-ball,

or cut off by the passage of a railway-train over it, the irregular and conical stump should be amputated, so as to leave a more useful and healthy one to the patient.

2. If the whole thickness of a limb—the soft parts and the bones—be thoroughly disorganized and crushed, it must be removed.

3. If the soft parts be extensively stripped away from the bones, though these be entire, so much sloughing and suppuration will ensue as to leave a useless limb, and amputation should be performed. It is in these cases that it is often especially difficult to estimate the amount of injury that cannot be recovered from, as so much depends upon the age and constitution of the sufferer. I believe that Surgeons, in their anxiety to save a limb, often lose a patient under these circumstances. I have more than once had reason to regret having attempted to save limbs injured in this way; and believe that, if the skin of the lower extremity be extensively torn down and the muscles much lacerated, so as to slough away, there is but little chance for the patient—unless he be young, and of a remarkably sound constitution—except in amputation. In the upper extremity it is different; there, recovery may take place under the most adverse circumstances. In all parts the dangers of attempting to save a limb have been greatly reduced by the antiseptic treatment. If decomposition of the sloughing tissues can be prevented, there will be little fever and but slight local inflammation, and the risk of pyæmia and erysipelas or other infective processes is scarcely appreciable. Supposing the attempt to save a useful limb to fail, if the antiseptic treatment is successful the chances of recovery are in no way impaired by the delay in amputating.

4. So also, if the knee be largely opened, with laceration of the soft parts and perhaps fracture of the contiguous bones, the limb must be amputated. Corresponding injuries of the ankle, shoulder, and elbow joints, may, as has already been stated, admit of resection rather than of amputation. In these cases also, the antiseptic treatment is an important aid in saving a limb, for if decomposition can be prevented, the mere fact that a joint is opened adds but little to the gravity of the case.

5. Bad crushes of the foot have a great tendency to run into gangrene, and hence require amputation. In the hand, on the contrary, very extensive injuries are often recovered from, without this operation being necessary; and in many cases partial resection may be substituted for it.

6. In those cases in which a large artery, as the femoral, is lacerated at the same time that the soft parts are extensively injured, and the bone fractured, amputation is required in order to prevent the occurrence of gangrene. In the more local form of traumatic gangrene, in which the disease is confined to the part directly crushed and injured, no good can come of delay, so amputation should be performed as soon as mortification has declared itself; and the limb must be removed at a sufficient distance from the seat of mischief. When the mortification results indirectly from injury of the vessels, the limb should also be immediately removed in a line with the wound, unless this be too high up; then the most favourable point must be seized, as will hereafter be explained. Amputation in these circumstances is by no means a very unfavourable operation (and it is one that I have several times successfully performed), provided it be done sufficiently early, before the constitution becomes poisoned by the absorption of septic matters from the gangrenous tissues. It is scarcely necessary to warn the Surgeon to be certain of the existence of gangrene before he

operates; and also that it be not a mere limited slough, but sufficiently extensive to jeopardize the patient's life.

7. In cases in which spreading gangrene attacks the wound early, amputation is the only hope of saving the patient.

The question as to the *period* at which amputation should be performed in contused wounds from gunshot will be considered at p. 349. It may be generally stated, that the sooner a condemned limb is taken off, the less is the suffering, and the better the chance of recovery of the patient; and that, consequently, primary amputation should be practised in these cases. By reference to the tables on p. 82, it will be seen that, although the average mortality for all primary operations is less than the average mortality for all secondary operations, yet primary amputation through the thigh is more fatal than secondary amputation in the same region. Notwithstanding this, it is absolutely necessary in many cases to remove the injured limb within the first twenty-four hours. The higher rate of mortality of primary thigh-amputations may be due chiefly to the greater severity of the injuries that manifestly require immediate operation, than of those in which it is thought justifiable to attempt to save a limb; and certainly, of the two alternatives—of leaving a badly crushed and mangled limb until suppuration has set in, and thus exposing the patient to all the risks of gangrene, erysipelas, pyæmia, &c., or removing it at once—the latter is the one attended with least danger to the patient.

A limb is sometimes so severely and hopelessly crushed and torn that any attempt at its preservation must be useless; whilst at the same time the patient is so severely injured internally, or is so prostrated by the general shock to the system, that amputation as a formal operation would be as useless as it would be unjustifiable, the patient having at most, perhaps, but a few hours to live. In these circumstances the best thing that can be done is to put on a tourniquet tightly, partly to restrain hæmorrhage, and partly to restrain the painful quivering of the muscles, and to wrap up the maimed limb in a wet cloth. Should the limb have been nearly completely detached—merely hanging on by shreds of the lacerated muscles—these may be divided, and its removal thus effected without additional shock or suffering.

Brush-Burn.—There is a peculiar species of wound, that partakes perhaps more of the characters of those wounds that we have just been considering than of any other, and is occasioned by rapid and severe friction of the surface of the body, so that the skin becomes abraded and the subjacent tissues somewhat contused. It goes by the name of a "brush-burn," and is not unfrequently produced in the manufacturing districts, by the surface of the body coming into contact with straps or portions of machinery in rapid revolution. It has also been known to occur in consequence of a person slipping and sliding rapidly down a long and steep Alpine snow-slope. In this injury the integumental structures are, as it were, ground off, and the areolar and aponeurotic structures converted into an eschar.

The *Treatment* presents nothing special, but may be conducted on ordinary principles. The separation of the eschars must be facilitated by moist antiseptic applications; the resulting sores will heal by granulation; and the general health must be supported during the suppurative period that must necessarily ensue.

STABS AND PUNCTURED WOUNDS.

These wounds, made by narrow sharp-pointed instruments, vary greatly in

extent, from the prick of a needle in the finger to a sword-thrust through the body. Not unfrequently punctured wounds are somewhat contused, being made by a triangular or wedge-like weapon, as a bayonet or lance-blade. When deep, they are of a most dangerous character—wounding blood-vessels, traversing the great cavities, and injuring the contained viscera. A punctured wound is extremely difficult to drain, the external orifice being very small in proportion to the area of the surface. Thus, if a narrow weapon half an inch in width were thrust into the thigh for a depth of six inches, the area of the two surfaces of the wound would be six square inches, while the external opening would be only half an inch in length. The small external opening is easily choked by a clot of blood, and is frequently injudiciously closed by the Surgeon. The whole track becomes distended with the blood or the serous exudation from the injured surfaces, and unless proper means are taken to prevent it, decomposition sets in, followed by inflammation and suppuration extending deeply into the injured part. In consequence of this, combined with the insufficient exit for the discharges, the pus may burrow deeply, large collections of septic matter may form, and severe constitutional disturbance is the necessary result.

Treatment.—In the treatment of punctured wounds, the principal points are to arrest the hæmorrhage, and to facilitate union.

The hæmorrhage must be arrested by pressure properly applied by means of compresses or pads, so as to approximate the sides of the puncture; by the application of cold; or by cutting down on the injured vessel if it be a large one, and ligaturing above and below the perforation in it.

In the majority of cases of severe punctured wounds suppuration and union by second intention will take place in consequence of the great difficulty in drainage. In order to obtain early union, the cavity should be washed out with carbolic-acid-lotion (1 in 40) or some other antiseptic, by means of an india-rubber tube on the end of a syringe. Care must be taken that there is plenty of room for the fluid injected to flow out rapidly, otherwise the spaces of the areolar tissue will become widely distended with the antiseptic solution; all superfluous lotion is then squeezed out, and a drainage tube inserted deeply into the wound. This may be shortened considerably after twenty-four hours, and gradually diminished day by day till it can be safely removed. The external application should be one of the forms of absorbent antiseptic dressing. On no account should a punctured wound be closed by collodion or any other occlusive application. The smallness of the external opening is apt to make the Surgeon forget the real extent of the injury. As the tube is shortened, the coalescence of the sides of the wound may be encouraged by properly applied compresses and bandages. The deep inflammation that so often follows these wounds is due solely to insufficient drainage and decomposition extending into the wound, and no treatment but the prevention of these conditions will exclude it. In former days, when duels with the small sword were of frequent occurrence, persons called "suckers," who were often the drummers of a regiment, were employed to attend the wounded combatants. Their treatment, which was conducted with a certain degree of mystery, consisted in sucking the wound till all blood ceased to flow, and then applying a pellet of chewed paper or a piece of wet linen to the orifice; in this way it would appear that many sword-thrusts traversing the limbs were healed in a few days. The process of suction cleared the wound thoroughly of all blood,

and, drawing the sides into close apposition, placed the parts in the most favourable condition possible for union by primary adhesion. This practice might, perhaps, in many cases be advantageously imitated in the present day by means of a cupping-glass and syringe.

Amongst the varieties of punctured wounds that are most commonly met with in ordinary practice are those which are occasioned by needles penetrating into, and breaking off in the body. These accidents occur chiefly in the fingers and feet, and about the nates; and, though trivial, are often extremely troublesome, both to the Surgeon and the patient. When the Surgeon is called shortly after the occurrence of the accident, he must endeavour to remove the fragment left behind, by cutting down upon it. In doing this he will be guided by the situation of the puncture, and by the seat of the pain, and sometimes by feeling the point projecting under the skin. In many cases this is a sufficiently simple proceeding; in others, however, a deep and troublesome dissection may be required, especially when the fragment of needle gets into or under the sheath of a tendon. I have had occasion to undertake somewhat troublesome dissections between the biceps tendon and the brachial artery, or in the close proximity of the ulnar artery, for the removal of fragments of needles lodged in the bend of the arm or of the wrist. For the purpose of extracting needles, thorns, splinters of wood, and other foreign bodies of small size and pointed shape lying in narrow wounds, the forceps shown in the annexed woodcut (Fig. 105) will be found most serviceable, as they have

Fig. 105.—Forceps for removing Small Pointed Bodies.

very fine but strong and well-serrated points. One of the most dangerous situations for a needle to penetrate is into the anterior part of the knee-joint, lodging in the head of the tibia or the patella, and breaking off short. In such cases the broken fragment should be dissected out at once, the strictest antiseptic precautions being adopted, so as to prevent inflammation of the joint. The limb must then be fixed firmly on a splint. I have known the most disastrous and disorganizing inflammation and suppuration of the knee-joint ensue, with imminent peril to life, and followed by ankylosis, in consequence of a portion of needle having been allowed to remain embedded in this situation for some days.

In many cases, if the needle have been lodged for some days, the Surgeon will fail in his endeavours to extract it; and, unless the indications of its presence be very clear, I think the wiser course would be to leave it undisturbed, and to trust to nature for its expulsion from the body, as it can seldom be found when sought for, and, indeed, may not exist, although supposed to be present. The following plan of ascertaining whether a portion of needle be really impacted has been suggested by Marshall. A powerful magnet is to be held upon the part for a quarter of an hour, so as to magnetize the fragment: a finely hung polarized needle should then be suspended over it, when, if any iron be present, deflection will ensue.

When a fish-hook, crochet-needle, or other barbed instrument has been run into the flesh, no attempt should be made to withdraw it through the aperture

by which it entered, but the point should be pushed on so as to emerge through the skin, the shank then divided by pliers, and the barbed end drawn out.

ARROW-WOUNDS occasionally fall under the observation of the military or colonial Surgeon as the result of injuries received in conflict with barbarous

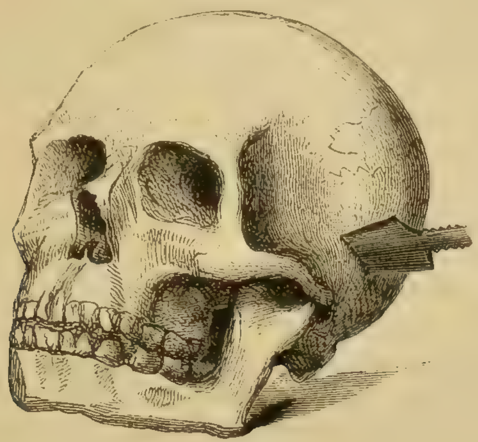


Fig. 106.—Indian Arrow penetrating temporal bone. Medical Department, United States Army.

races. They differ only in one essential respect from penetrating punctured wounds received by knife-stabs and sword-thrusts, viz., that the arrow-head will remain impacted in the tissues it has penetrated. The force with which an arrow may be shot is well illustrated in the accompanying figures (106, 107) taken from preparations in the Army Museum at Washington. The arrow shot from the bow of a North American Indian has been known to traverse the body of a buffalo and penetrate the under surface of its scapula, as illustrated by a preparation in the Museum at Washington.

The extraction of an arrow is usually attended by little difficulty. But if

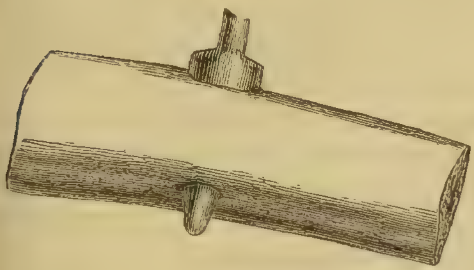


Fig. 107.—Buffalo Rib pierced by Indian Arrow. (U. S. Army Med. Dep.)

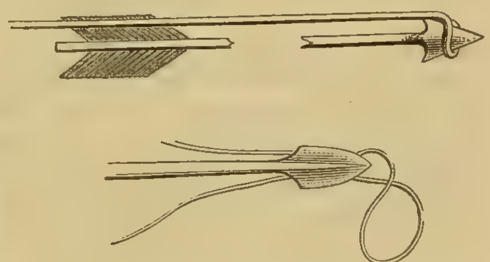


Fig. 108.—Bill's Snare for Extraction of Arrow-Heads.

barbed, or if the shaft becomes detached from the head, then special precautions have to be taken. With the view of safely effecting its removal, the "snares" figured (Fig. 108) have been devised.

CHAPTER X.

GUN-SHOT WOUNDS.

Of the special varieties of contused and lacerated wounds, none are of more interest than the different forms of gun-shot injury. Though comparatively rare in civil practice in this country, yet gun-shot wounds are of sufficiently frequent occurrence to render an acquaintance with them indispensable to the general Surgeon. To the military Surgeon the study of them is necessarily one of peculiar interest and importance; and to him I would specially recommend the perusal of the works of Macleod, Longmore, Stromeyer, Esmarch, Fischer, and other Surgeons who have had unusual opportunities of studying the nature of these injuries on the field of battle, and by whom they have been considered with all the minuteness of a speciality. The works of Guthrie, Hennen, and Larrey, whose experience was gained in the wars at the early part of the present century, are well worthy of study, and much that is interesting will be found also in the writings of Ambroise Paré, Wiseman, and John Hunter.

I purpose in the following observations to confine myself chiefly to such a general discussion of the subject as is required by the civil Surgeon.

Gun-shot injuries constitute a species of contused and lacerated wounds, often partaking also of the nature of punctured wounds in the disproportion between the subcutaneous mischief and the external aperture. They are characterized in some cases by the peculiar appearance presented by the colour, shape, and size of the orifice; and in others by the extensive injury inflicted on the tissues, both superficial and deep-seated, in consequence of which the wounds may prove rapidly or immediately fatal. If the sufferer survive the immediate effects of the injury, acute inflammation with much pain and tension, deep-seated suppuration, profuse discharge, and other serious and very protracted after-consequences, are apt to supervene. These peculiarities have at different times been attributed to the parts being burnt by the ball, to the poisonous nature of projectiles, to the generation of electricity in the bullet during its passage through the air, or by its friction against the barrel. All these opinions, however, have been shown to be erroneous; and every peculiarity presented by these injuries can be accounted for by the bluntness of the contusing body, the rapidity of its motion, the force with which it is driven, and by the insufficient exit for the decomposing discharges that necessarily accumulate in the track of the bullet, unless some means be taken to prevent it. That the sloughing which almost always occurs in the track of a bullet is due to the bluntness of the body with which the injury is inflicted, and not to any peculiarity arising from its being propelled by gunpowder, is evident from the fact that sharp splinters of shell have been known to inflict clean-cut wounds. As John Bell has pithily remarked, "There is a peculiarity, but no mystery, in gun-shot wounds."

Characters.—Gun-shot wounds vary greatly according to the Nature of

the Projectiles, the Force with which they are driven, and the Direction in which they strike.

Nature and Force of Projectile.—Gun-shot injuries of a serious character may be inflicted by *weapons charged only with powder.* They may arise from the mere concussion of the explosion ; thus a pistol charged with powder, and discharged with the muzzle resting against the chest of a man, has been known to kill by concussing the heart. In other cases, a portion of the unexploded powder may be driven into or even through the skin by that which is exploded behind it. In this way, very troublesome and disfiguring marks are sometimes inflicted on the face, and other parts of the body, by the charcoal of the powder lodging in the skin. That a weapon so charged may actually kill when discharged at a little distance appears from a case related by Dupuytren, in which a fowling-piece charged with powder only, and fired at the distance of two or three feet from the abdomen, pierced the belly with a round hole and killed the man. The mere force of the explosion will sometimes produce serious lacerations. Suicides occasionally forget to put a bullet into the pistol, and firing into their mouths, blow open the cheeks, and injure the pharynx and glottis by the explosive force. Some years ago, a man was brought to University College Hospital, who had discharged some powder from the tube of an Italian iron into his mouth, and he died in consequence of the injuries he received. In another case in the same Institution, a man died, on the fifth day after firing a pistol into his mouth, of asphyxia, occasioned by sloughing of the pharynx and inflammation of the glottis and larynx, consequent on the scorch of the explosion.

Wadding and soft materials, as pieces of clothing, will occasionally inflict serious wounds by the force with which they are driven. These injuries often happen on the stage, at reviews, fairs, &c. Taylor relates several instances of the kind :—one of a girl killed by a gun charged with paper pellets ; also, one of a man who was killed by a kid glove fired from a blunderbuss.

Small shot often inflict serious injuries, and these are most commonly met with in civil practice. If the person wounded be within a few feet of the muzzle of the gun, a terribly torn and lacerated wound, even worse than that occasioned by a bullet, will be inflicted ; for the shot, not being scattered, are driven through the body in a comparatively compact mass, and tear the tissues to a great extent. The compactness of a charge of shot when striking close to the muzzle of the gun may be very remarkable, making a wound like that of a bullet. A lad was admitted into University College Hospital under my care, who had accidentally shot himself. The whole charge had passed from before backwards between the skin of the inner side of the arm and the brachial vessels and the accompanying nerves, leaving a bridge of skin about three inches in width and the vessels and nerves uninjured, the triceps, however, being torn. The patient made an excellent recovery.

When shots scatter as they fly, they produce at a greater distance a less serious injury, usually lodging in the subcutaneous areolar tissue, where they may remain for years, requiring to be picked out with a lancet ; or they may give rise to suppuration. Occasionally, shot, by penetrating an important part, may cause serious or fatal results ; thus, a single shot penetrating the eyeball will destroy vision ; or, lodging in the heart or in the femoral vein or other large vessel, may give rise to rapidly fatal results. A patient was once brought to University College Hospital, who had fired a pocket-pistol loaded

with small shot into his mouth ; after death, the shots were found to have penetrated the anterior portion of the vertebral column, in which they were deeply lodged.

Splinters of metal, wood, or stone, carried by the force of an explosion, as in blasting and mining operations, may inflict grave injuries. These latter inflict perhaps the worst forms of injury from bodies propelled by explosive force that are met with in civil practice. In siege-operations much injury is often inflicted also by the splinters from parapets, or by the forcible throwing up of gravel and small stones by the explosion of shells. In naval actions too, the force with which splinters of wood are driven, when struck and scattered by cannon-shot, is often so great as to inflict the most serious and fatal mischief. A particular form of injury sometimes met with in civil practice, and which belongs to this class, is a wound of the eyeball by the explosion and splintering of faulty percussion-caps. Wounds of the face and other parts from the splashes or splinters of bullets from the surface of targets are of common occurrence among markers at rifle-ranges.

Slugs are irregular bits of lead of no definite form or size. They produce wounds more ragged than small shot, but, unless fired at very short range, they seldom penetrate deeply. The experience of the Ashantee War, in which the natives used slugs almost exclusively, showed that the proportion of severe to slight wounds was very small, the projectile not having sufficient power to break a large bone.

Bullets occasion more serious wounds, lacerating soft parts, fracturing and crushing bones, tearing asunder vessels and nerves, perforating the viscera, and occasionally cutting off parts, as a finger, the nose, or an ear.

Fig. 109.—Perforation of Right Femur by Bullet. Longitudinal Splitting of Bone. (United States Army Museum.)

The general introduction of rifled fire-arms into modern warfare has greatly increased the destructive effects of bullets. The missile is now comparatively rarely deflected from its course by the resistance offered by bones, tendons, or by the elastic reaction of the skin, as happened with the spherical ball, but penetrates in a straight line from the point struck, tearing through the soft parts, and splintering the bones extensively. On the bones especially, the modern *conico-cylindrical bullet* produces the most destructive effects ; not only comminuting the part struck, but often splitting up the shaft of the bone, by its wedge-like action, in fissures many inches long, leading into contiguous joints (Fig. 109). In consequence of the more extensive injury, the shock to the nervous system is greater when a person is struck by a conico-cylindrical than by a spherical ball.

Direction.—In the majority of cases, a bullet traverses the part struck, and the wound has two apertures—one of entry, the other of exit ; occasionally it happens, however, that in consequence of the ball being spent, or of the piece not having been efficiently loaded, or of the oblique direction with which the ball strikes the part, it leaves merely a contusion or dent, rebounding or glancing off. In other cases there is only one aperture ; and here the bullet, partly spent, has probably lodged in the soft tissues, or in a bone, or in the cavity of a hollow organ, as the bladder. It some-

times happens, however, that the ball drops out through the aperture at which it entered, as when a spent ball strikes a rib; or that it carries a pouch of clothing before it, which enables the Surgeon to withdraw it. One bullet may make even more than two apertures; thus a round ball has been known to split against the sharp edge of the tibia, and to have one aperture of entry and two of exit; or it may pass through both thighs or both calves, and thus occasion four apertures; and cases have been recorded in which five wounds even have been made in the same person by one bullet.

The direction of the openings is often of importance in a medico-legal as well as in a surgical point of view. Thus, Sir Astley Cooper, by attending to this circumstance in a case of murder, ascertained that the fatal shot must have been fired by a left-handed man; and this led to the detection of the criminal. These apertures, though usually opposite to one another when a ball passes right through a part, are not always so, the bullet being deflected by the bones, or by the elasticity of the skin, so that the two apertures do not correspond. Thus a spherical bullet has been known to strike a rib and to be then deflected, running under the skin to the opposite side of the body; again, striking one temple, a bullet has been carried under the scalp to the other side of the head, where it has passed out; thus it might appear, that important cavities had been penetrated when in reality they had not been wounded.

The **Apertures of Entry and of Exit**, made by a bullet, deserve attentive consideration. Much discussion has arisen as to whether there be any difference between these apertures, and, if so, to what it is owing. That there is a difference in the great majority of cases there can be no doubt; though this difference is, as a rule, not so decided in the case of the modern rifle-ball as in that of the spherical. Thus, in the latter instance, the hole made by the entrance of the bullet is small, circular in shape, less than the diameter of the ball in breadth, the edges being slightly inverted and ecchymosed (Fig. 110); whereas, in the former, the aperture of entry is more lacerated and irregular in outline, often linear, crucial, or starred, and larger than the diameter of the ball. In either case, the hole made by the exit of the ball is a large, somewhat everted, and irregular aperture, into which two or three fingers may be freely passed (Fig. 111). In some cases, however, there is no appreciable difference between the two; and in others, as a result of sloughing, the aperture of entry may, after a time, become larger than that of exit.

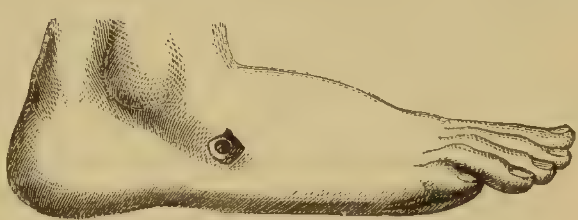


Fig. 110.—Gun-shot Wound. Aperture of Entry.

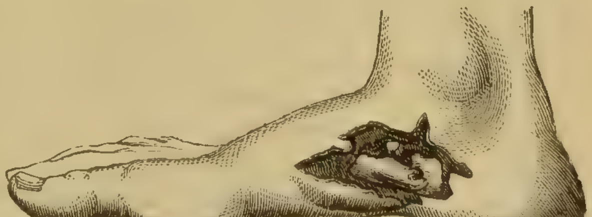


Fig. 111.—Gun-shot Wound. Aperture of Exit.

There can be no doubt that Guthrie has given the correct explanation of

these discrepancies, when he states, that the amount of the difference in the two apertures will depend partly on the momentum of the ball, and partly on the resistance with which it meets. If the ball strike shortly after its discharge, at the maximum of its velocity, it will make but a small round hole, not shattering the parts so much as separating them. If it traverse a part composed of soft tissue, meeting with but little resistance in its passage, it loses but little of its momentum; and passing out of the body with nearly the same force as that with which it entered, it makes an aperture of exit that differs but slightly, if at all, from that of entry. If the ball strike a bone in its passage through the limb or body, and thus, by meeting with much resistance, have its momentum materially lessened, the aperture of exit will be torn, large, and ragged, differing materially from that of entry. But in addition to the conditions given by Guthrie, there are two other circumstances that tend to occasion a difference between the apertures of entry and of exit. The first is, that the bullet as it traverses carries with it a mass of foreign material, pieces of clothing, shreds of tendons, splinters of bone, which, driven along by the velocity communicated to them by the ball, distend and widely separate the distant parts of the wound, and thus cause the aperture of exit, near and in which they will be found to be lodged, to be larger than that of entry, which has admitted only the bullet. The aperture of entry is made solely by the ball; the aperture of exit is made by it, plus the débris that it carries along with it. A further reason for the difference in size between the two apertures is this, that the wide tearing-asunder of the tissues at the aperture of exit is greatly due to their want of support. The part first struck has as a support the whole thickness of the limb or the body. That which is last perforated has no such support behind it, and is thus largely torn or splintered outwards. This is exactly what happens if we drive a nail through a board. If supported by another piece of wood, the apertures on the two sides are even and of the same size. If unsupported, the aperture on the distant side—that of exit, in fact—will be splintered, irregular in shape, and larger than that of entry.

In wounds made by spherical bullets the entrance-aperture is often actually less in diameter than the bullet itself, provided it be made whilst the ball is moving with its full velocity; but if the ball have lost much of its momentum before it strikes, then the entrance-wound will always be large and ragged. In this there is nothing peculiar to the tissues of the living body; the same happens when any elastic material, as a piece of green timber, is struck. Much, however, will depend also on the period at which the wound is examined. In the early stages, for the reasons mentioned, the wound of entry may be smaller than that of exit; but, as the slough which forms in the wound of entry is larger than that at the exit-aperture, the former may, in a later stage, appear larger than the latter. This difference in the size of the two wounds I saw well exemplified in the case of a young man, shot through the neck with a pistol-ball in a duel. The aperture of entry, which was at first the smaller, appeared on the second day the larger in consequence of the extrusion of a black slough; though it continued more regular in shape than that of exit.

Shrapnel bullets, case-shot, and **grape-shot** differ from the old spherical bullets only in their greater size, and the effects they produce are similar but more extensive. The Mitrailleuse, Gatling, and Nordenfelt guns fire a conical

ball of considerable size; but happily little experience has as yet been gained of their effects on the human body.

Fragments of **Shell**, if of large size, inflict the most terrible wounds met with in military practice, tearing off whole limbs, or great masses of flesh, and splintering the bones in all directions. At the battle of Sedan, after the Prussians had shelled a crowded mass of French troops, the ground was described as covered with "heaps of flesh and rags." A small fragment may either become lodged, or make its way out, the aperture of entry being somewhat incised, though very irregular, and the aperture of exit large and ragged.

The old round **Cannon-ball**, in fact, solid shot of all kinds, are now quite abandoned in war, being replaced by shells fired from rifled cannon. The old cannon-balls inflicted two kinds of injury. Sometimes they contused a part deeply, crushing muscles and bones, without destroying the integrity of the skin, the ball either having lost its velocity—being "spent"—or striking obliquely, and rolling over the surface of the body. The elasticity of the skin preserved this from injury, though all the subjacent textures—bones, muscles, and vessels—might be crushed into a pulp, if a limb were struck; if the trunk itself were injured, the vertebral column and lumbar muscles might be disorganized, and the liver, kidneys, spleen, stomach, and intestines ruptured without any breach of surface. These injuries, formerly erroneously attributed to the action of the current of air set in motion by the ball, are known by the name of *wind-contusions*. Subcutaneous contusions of similar character, though less severe in degree, may be produced also by spent bullets. In some of these contusions, gangrene of the limb set in; apparently, as Guthrie pointed out, from the rupture of the principal vessels. Cannon-shot more commonly carried away the whole thickness of a part, tearing and shattering a limb, carrying off the thick and fleshy parts of thigh, calf, or shoulder; or they inflicted the most fearful injuries by smashing the trunk and head.

SYMPTOMS.—The chief peculiarities of gun-shot injuries consist in the amount and character of the Pain, the severity of the Shock, the comparatively little liability to Hæmorrhage, and the severity of the Consecutive Inflammation.

The **Pain** in gun-shot injuries varies greatly. It is most severe when a bone is fractured, or a large cavity penetrated; when soft structures alone are injured, a dull and heavy sensation is experienced, which has often been compared to that occasioned by a blow with a stick. In many cases, however, the sufferer is not aware that he is shot till he is told of it. I have known a person, shot in the leg by a pistol-ball, unaware that he was wounded till told that his leg was bleeding. This is especially apt to happen when the mind is actively engaged, as in the height of battle. Hennen has known a limb carried off or smashed to pieces by a cannon-shot, without the sufferer being conscious of it; and Macleod relates the case of an officer who, in the Crimea, had both legs carried away, and who was not aware of the injury till he tried to rise.

In gun-shot injuries, **Shock** is always very marked when parts of importance, as the head, chest, and abdomen, or large joints, as the knee, are opened; and its severity is indicative of the amount of mischief inflicted. Thus, if a bullet appear to have traversed the chest, but in reality has been deflected under the skin, the comparative absence of shock will serve, to a certain extent, to prove that visceral mischief has not been inflicted. As before

stated, a wound from a conical ball causes more shock than a corresponding injury from a spherical bullet, as the extent of the damage done by the former is always greater. In some cases the shock alone appears sufficient to kill; thus, a man shot by a pistol-bullet, which traversed the distended stomach, died in a few seconds from shock, there being no bleeding of importance, or other discernible cause of immediate death (Taylor). In some cases, however, that are mortal, the symptoms of shock are but slight.

The **Primary Hæmorrhage** from gun-shot-wounds varies necessarily according to the situation of the injury and the size of the vessels injured: *cæteris paribus*, these wounds bleed less than other injuries; but in all cases a certain, and in many a large and fatal, quantity of blood is lost. When the fleshy parts of a limb are perforated by a bullet, the hæmorrhage is usually very trifling, the vessels divided being small, and contused rather than cut across. But, though it may be stated as a general rule that gun-shot-wounds do not bleed much, yet when a large artery, as the carotid, iliac, or femoral, is torn across, violent and rapidly fatal hæmorrhage will occur—the vessel bleeding as freely as if divided with the knife. Bullet-wounds of the large and deep arteries of the chest and abdomen are almost immediately fatal from hæmorrhage. The greater number of those who die on the field of battle perish from this cause. It has often been observed that arteries escape, though lying apparently in the direct track of a ball. In such cases, however, though primary hæmorrhage do not occur, the liability to secondary hæmorrhage is great, in consequence of the artery, which has been contused by the passage of the bullet, sloughing at a later period. If the whole of a limb be torn away by a cannon-shot, the arteries of the jagged stump do not bleed, for the same reasons that those of a limb torn away by machinery do not; viz., the contraction and retraction of the ruptured internal and middle coats, and the twisting of the external cellular coat over them.

Gun-shot-wounds, under ordinary circumstances **Inflame**, with much **Swelling, Infiltration,** and **Tension.** That this should be the case is not surprising when we consider the nature of the wound and the mode of its infliction. The tissues through which the bullet passes are violently contused, the parts actually touched by the projectile are killed, and those a little more remote are bruised and damaged to such an extent that if exposed to any further irritation, as tension or the presence of putrid matter, they readily perish. The bones, if they lie in the track of the bullet, are splintered and fissured, and the fragments are displaced and driven into the surrounding soft parts. At the same time the hæmorrhage which takes place finds but an imperfect exit from the apertures of the wound, and the intermuscular planes of a limb and any cavity that may be opened become distended with extravasated blood. The exudation from the injured soft parts, that necessarily follows immediately on the injury, still further distends the part with putrescible fluid. As the nature of the external wound renders it impossible for it to heal by first intention the whole of this decomposable matter is freely in communication with the external air, and the ferments contained in the atmospheric dust find admission from without. This is often rendered even more certain by pieces of clothing and other foreign bodies being lodged deeply in the track of the bullet. By the third day, therefore, we have developed in a gun-shot wound, unless special means are taken to prevent it, one of the most dangerous conditions to which a patient can be exposed—a

large accumulation of putrid matter, deeply situated, with a totally insufficient exit for the discharges. If a bone be broken, or a joint or one of the natural cavities of the body be opened, the condition is so much the worse. The bullet damages only the parts it touches ; the extension of the inflammation beyond these parts is entirely due to pent-up and putrid discharges. The extent of tissue actually killed by the contact of the ball is comparatively limited ; the wide-spread sloughing that may follow a gun-shot wound is due to the irritation of tension and of the chemical products of putrefaction.

The ordinary course of a gun-shot wound is as follows :—As soon as the patient has rallied from the shock the temperature begins to rise above normal. By the second day the inflammation, consequent upon the irritation of putrid matter and the tension caused by the abundant exudation from the injured tissues, begins to manifest itself. The pain, which at the moment of infliction may have been but slight, becomes extremely acute, owing principally to the great tension. By the third day suppuration sets in, often most profuse and extensive, not only in the track of the ball, but widely diffused through the neighbouring parts. The discharges are offensive from putrefaction and find a very imperfect exit by the comparatively narrow openings of the wound. Consequently the patient suffers severely from the absorption of septic matter, the fever being very high and the constitutional disturbance very great ; in fact, many die about this time from septic poisoning. Should a more ready exit be established for the discharges, the fever subsides by about the tenth day, as granulations spring up and limit the absorption of the products of putrefaction. A period of great danger in gun-shot-wounds is that during which the sloughs separate, usually from the sixth to the twentieth day : and before this time it is often impossible to ascertain the precise extent of the disorganization. At this period, also, **Consecutive Hæmorrhage** is very apt to come on, even after very slight exertion, without any warning. Baudens states that this occurrence is most likely to happen on the sixth day. This may be suddenly fatal, and is always more dangerous than the primary hæmorrhage, not only on account of the difficulty of arresting it, but because the patient has been already weakened by severe inflammation and suppuration. Secondary hæmorrhage may occur from causes other than the separation of the sloughs and the consequent opening up of a contused or inflamed artery. It may take place from an artery wounded by a spiculum of fractured bone ; and, from the same cause, it may arise at any period until all detached bone is separated and the wound firmly cicatrized. Chisholm, of the American Confederate army, mentions a case of death from secondary hæmorrhage on the 328th day after a gun-shot-fracture of the upper third of the thigh, owing to a wound of the femoral artery by a detached sequestrum. Independently of this danger from secondary hæmorrhage, the patient, if his limb be saved, may have to undergo long and tedious processes of exfoliation of dead bone, and to run the risk of intercurrent attacks of erysipelas, hospital gangrene, and pyæmia.

Although a bullet-wound in the vast majority of cases follows the course above described, inflammation and profuse suppuration is not an inevitable result. Middleton Michel of Charlestown, U.S.A., relates many cases in which gun-shot wounds, inflicted by the Minié rifle-bullet, healed without suppuration even when the bones were injured. Such cases are sufficient evidence that the destruction of tissue caused directly by the action of the bullet is not so exten-

sive as was at one time supposed, and that, could perfect drainage be combined with prevention of decomposition, gun-shot wounds would be robbed of half their dangers.

There is every reason to believe that warfare in modern times is fully as destructive to life as it was formerly, if not much more so ; not in the proportion of the killed to the number of combatants engaged, but in relation to the recoveries among the wounded. This at first sight appears remarkable, when we consider the great advances that have of late years been made in surgical treatment and in sanitary arrangements. But unfortunately the means by which these great advances have been brought about are seldom at the command of the military surgeon. A very large proportion of all gun-shot wounds must occur under circumstances which render antiseptic treatment uncertain or impossible ; whilst the enormous number of men engaged has yielded so large a number of sick and wounded that, after the first few weeks, the sanitary arrangements have hitherto broken down under the pressure, and secondary septic diseases have committed the most frightful ravages. Moreover the size and form of the projectiles now used, and the force with which they are driven, are such as to render the wounds inflicted by them infinitely more destructive than they used to be ; and the advance in surgical treatment is thus more than neutralized by the more deadly nature of the injuries.

Treatment.—The slighter and purely superficial gun-shot injuries generally require merely to be treated on the ordinary principles that guide us in the management of contusions and lacerations generally. When they affect the head, chest, or abdomen, they present so many circumstances of special importance, that we must defer the consideration of them until we treat of injuries of those regions.

In all cases of gun-shot-wound, whether amputation be ultimately required or not, certain *immediate attentions* are necessary in order to place the sufferer in some degree of comfort and safety until more definite treatment can be adopted. Thus, if a person be shot through the fleshy part of a limb, no bone or vessel of importance being injured, the part should, if possible, be well washed or syringed with a 1 in 20 solution of carbolic acid in water, or with chloride of zinc, 20 grains to the ounce, and then covered with a pad of salicylic wool, or jute, carbolized jute, iodoform wool, or some other dry antiseptic dressing, or a pad of lint soaked in the carbolic lotion may be applied and the limb placed in an easy position. In actual warfare a solution of chloride of zinc, prepared from the solid salt as needed, appears to be the most practically useful antiseptic. If a bone or joint be injured, the same plan must be adopted, and the limb placed on a splint of some kind, extemporized from such material as may be at hand. A bayonet forms a useful splint for the leg, arm, or fore-arm ; and for the thigh a rifle may be applied to the outer side of the limb with the stock against the side of the body. Above all no finger or probe must be thrust into the wound till the examination can be accompanied by proper antiseptic precautions.

If there be abundant venous hæmorrhage, the limb should be raised ; and if this do not arrest the bleeding, a compress should be used. If the hæmorrhage be arterial, a tourniquet must be applied. So, also, a tourniquet should be employed if there be rapid dripping of blood.

If a limb be smashed, or torn away, a tourniquet should be applied very

tightly upon the stump, which must be covered up in wet cloths. The pressure of the tourniquet will not only arrest hæmorrhage, but will stay that spasmodic quivering of the muscles of the mangled limb which is so painful to the sufferer.

If the head or neck be wounded, the wound must be treated as above described, and hæmorrhage, whether venous or arterial, should be arrested by pressure with the fingers.

If the chest be shot through, the patient should be laid on the injured side, and cold employed. If emphysema occur, or if air freely pass through the wound, a body-bandage must be tightly applied.

If the abdomen be wounded, the patient should be laid on the injured side, if the aperture be lateral; if it be central, on his back, with the knees bent over a log or knapsack, or other support. If the intestine protrude, it must be washed and returned at once.

In addition to those immediate attentions which may be bestowed upon sufferers from gun-shot wounds before they are sent to the hospital for more methodical treatment, the influence of the shock and pain should be counteracted by the administration of a little brandy-and-water and opium, and plenty of cold water should be given to allay thirst.

Gun-shot Wounds of the Extremities may be divided into two great classes in reference to treatment :—I. Those that do not require amputation; II. Those in which amputation is necessary.

I. Those cases of gun-shot injury that **do not require amputation** must be treated on the principles that guide us in the management of all contused and lacerated wounds; the Surgeon bearing in mind, however, that these injuries are especially apt to be followed by extensive and intense inflammation, and that sloughing is very prone to occur in every part that has been touched by the ball.

The first point to be attended to in these cases is the **Arrest of Hæmorrhage.** In general, this may not give much trouble; but, if a large vessel be injured, the loss of blood will rapidly prove fatal, unless immediately stopped. The bleeding may in the first instance be stopped by direct pressure with the fingers on the bleeding part, followed by the application of the tourniquet, the most convenient form being the simple elastic band. If this be not at hand, some substitute must be made use of, such as a pebble, of about the size of an egg, rolled in the middle of a pocket-handkerchief and laid over the artery, the handkerchief being knotted round the limb, and then twisted up tightly with a piece of stick or the hilt of a sword passed under it (Fig. 112). The wound in the artery may render amputation of the limb necessary; if not, hæmor-

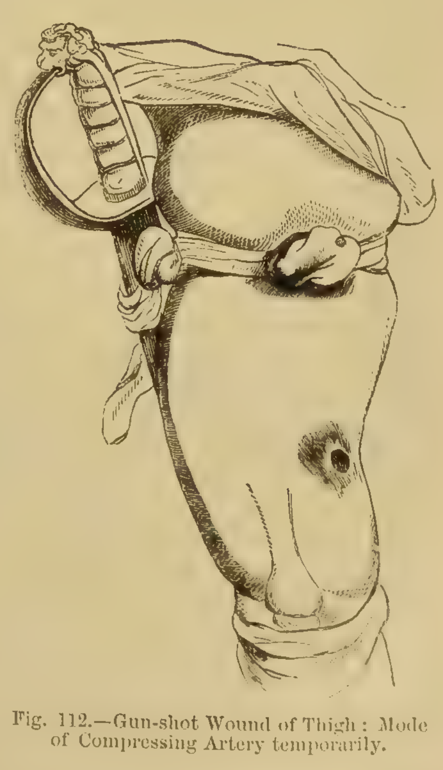


Fig. 112.—Gun-shot Wound of Thigh: Mode of Compressing Artery temporarily.

rhage must be permanently arrested by making an incision down to the bleeding vessel, and applying a ligature on each side of the wound, for reasons that will be fully stated when we come to speak of Injuries of Arteries. In military practice such operations, however, appear to be very rare, and the ligature of a large artery for primary hæmorrhage after gun-shot injury is scarcely ever practised. The fact is that, if a large artery be wounded, the patient usually dies outright from hæmorrhage before anything can be done to arrest it. If a small vessel only be divided, the hæmorrhage will speedily cease of itself.

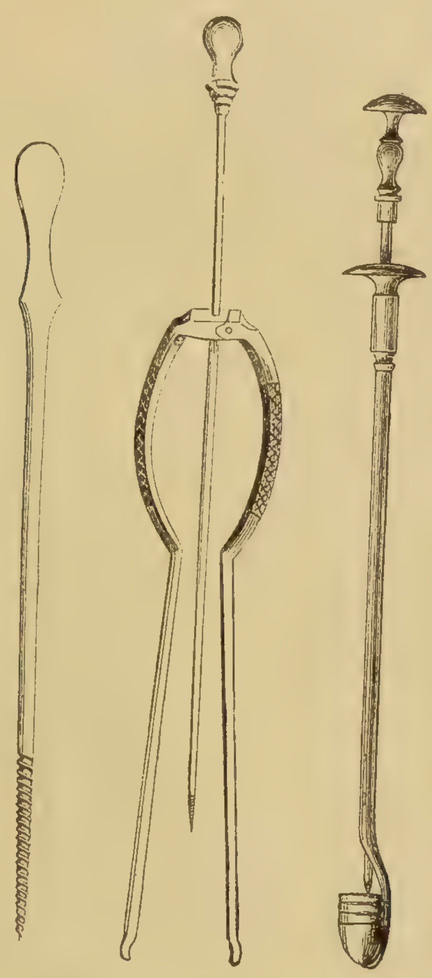
The second point to be attended to is the **Extraction of Foreign Bodies**, such as shot, slugs, or bullets, wadding, pieces of clothing that have been carried in with the ball, splinters of bone, and other matters of a like kind. These will generally be found near the aperture of exit, through which they may often be more easily extracted.

If the *bullet* lodge, it, together with foreign bodies accompanying it, such as pieces of clothing, must be extracted through the wound, or cut out by a counter-opening. This second opening is often of great utility in affording a ready exit for subsequent discharges, &c. Palpation of the limb or region struck will often lead to the discovery of the bullet, when it lies amongst the muscles or beneath the skin. A consideration of the direction whence the bullet came, and the position of the patient when hit, will often direct attention to the spot where the ball has lodged. If possible, the same position of body or limb should be assumed; the track of the bullet will thus be straightened, and the finger or probe can be carried down to it more readily. In searching for bullets and other foreign bodies, care should be taken not to probe the wound unnecessarily from mere curiosity, or so as to excite irritation; in many cases, the introduction of the finger is far more useful than that of the probe. The advice given by Ambroise Paré, three hundred years ago, with regard to the examination of gun-shot wounds, can scarcely be improved upon. After advising that the examination of the wound be made as soon after the injury as possible, before swelling and inflammation set in, he says: "This is the principal thing in the performance of this work, that you place the patient in just such a posture as he was in at the receiving of the wound; for otherwise the various motions and turnings of the muscles will either hinder or straighten the passage forth of the contained bodies. You shall, if it be possible, search for these bodies with your finger, that you may the more certainly and exactly perceive them. Yet, if the bullet be entered somewhat deep in, then you shall search for it with a round and blunt probe, lest you put the patient to pain." The *extraction of the bullet* should be accomplished without delay, before inflammation has set in, and the lips and sides of the wound have become swollen. As Macleod justly observes, the extraction of the ball not only removes a source of physical irritation and suffering, but also of mental disquietude. The mind of the patient becomes more tranquil and easy. Bullets cannot be allowed to remain lodged in the body with impunity. It is true that in some cases they become encysted, and so cease to irritate; but in the great majority of instances they produce suffering and constitutional disturbance, and may at last occasion fatal mischief; for, although a bullet may continue fixed for years, yet it may at last, under the influence of muscular action, gravity, or the absorption of fat, begin to move and to give rise to injurious consequences. If any foreign body be very tightly fixed, so that it

cannot easily be removed, it must be left till loosened by suppuration. Sometimes a bullet is firmly fixed in the cancellous structure of the articular end of a bone. It may be removed thence by means of an elevator or by the screw-probe.

Various instruments are used for the detection and removal of bullets and other foreign bodies. There is usually no material difficulty in detecting the presence of a bullet, by means of an ordinary steel probe of sufficient length. In some cases of peculiar and exceptional difficulty, where the bullet is lodged deeply in the cancellous structure of a bone, or amongst swollen and infiltrated

Fig. 113.—Nélaton's Probe.



Figs. 114, 115, 116.—Bullet-screw, Forceps, and Extractor.

Fig. 117.—Bullet-Forceps.

Fig. 118.—Hook Splinter-Forceps.

tissues, its presence may be detected by the ingenious device adopted by Nélaton in the case of Garibaldi, of passing a probe, armed with a piece of unglazed porcelain, down to the suspected site of the bullet, and seeing if a streak of lead were left on the rough surface of the china (Fig. 113). Bullet-detectors have also been contrived, in which, by an arrangement of two insulated metal probes in a cannula connected with a galvanometer, the galvanic circuit is completed when the bullet is touched, and the needle of the galvanometer, deflected; or, instead of the latter instrument, the ordinary telegraph-

alarum may be interposed, the bell of which rings when the circuit is completed by the bullet or any other metallic body being touched. These various contrivances are more ingenious than practical, and may be looked upon as surgical toys rather than as useful instruments. For the removal of bullets, long and strong forceps are required, the action of which may be aided by a screw probe. The accompanying woodcuts (Figs. 113, 114, 115, 116, 117 and 118) represent the best forms of bullet-screws, forceps, and extractors.

The *splinters* produced by the passage of a ball through a bone are more numerous and larger when the injury has been inflicted by a conical rifle-ball. The impetus of this projectile is so great, and its wedge-like action so destructive, that the bone struck is shattered into a number of fragments, as well as split longitudinally, often to a great extent. These fragments are detached to a greater or less extent from their connections with the soft parts, and carried out of the axis of the limb. Dupuytren, who was fond of systematizing, has classified splinters of this kind under the three heads of *primary*, *secondary*, and *tertiary*. By *primary* splinters are meant those which are carried completely across the limb, detached from the soft parts, and lodged near the aperture of exit. The *secondary* splinters are those which are still attached by a strip of periosteum or fibrous tissue; and the *tertiary* are those portions of bone which, from the violence done to them, often necrose and separate at a subsequent period. The treatment of these different kinds of splinters must necessarily vary. The primary, which are already completely detached and are incapable of consolidation, must be treated as foreign bodies and extracted. The secondary, if very loose, must also be removed; but, if more firmly fixed, they may be pushed into the axis of the injured bone and left, when they may become consolidated by callus, and so serve in the reconstruction of the bone. The tertiary, which do not separate until about six or seven weeks, must be removed as soon as possible; if they become engaged in a mass of callus, it may be a considerable time before they are loose enough to be removed; and, until then, sinuses leading down to them will remain open even for years.

The reunion of comminuted gun-shot fractures may be assisted by the resection of the fractured ends of the bones, in appropriate cases. This plan has been especially successful in the bones of the upper extremities. The ends thus resected may furthermore be kept in apposition by metallic sutures, according to the plan suggested by Howard, of the American army.

In those cases in which small shot are lodged under the skin, they may be turned out by being cut down to with a fine scalpel.

The **Treatment of the Wound** itself must be conducted on ordinary surgical principles. As has already been stated, there will, as a rule, be violent inflammation and sloughing along the whole track of the ball, unless decomposition can be prevented and drainage perfectly established; although instances have been recorded of primary union in gun-shot wounds, uncomplicated with fracture or the lodgment of foreign bodies, even without any special mode of antiseptic treatment. The principal points to be attended to are, to limit inflammation by rest, drainage, and the use of antiseptics, to watch and facilitate the separation of sloughs should they form, and to pay scrupulous attention to cleanliness and the general hygienic surroundings of the patient.

By adopting when possible some form of *antiseptic treatment*, inflammation may be limited, and the formation of sloughs avoided; in both civil and

military practice the repair of gun-shot fractures without suppuration has been frequently obtained by this mode of dressing.

In cases occurring in civil practice the employment of antiseptics with all needful precautions is easy, and the results are correspondingly satisfactory. Kraske has published a series of twenty-three cases occurring under the care of Volkmann in Halle, treated by strict antiseptic dressing with enlargement of the apertures, both of entry and exit, to facilitate drainage. Of these two died—one a perforating wound of the skull, and one wound of the abdomen perforating the liver, kidney, and pleura. The twenty-one cases that recovered were the following: five flesh wounds, two flesh wounds requiring primary ligature of the femoral artery for hæmorrhage, two of the arm, with fracture, four wounds of the knee-joint; two perforating wounds of the skull, and six of the chest.

In military practice the circumstances are usually such as to render the use of antiseptics difficult, if not impracticable, except to a very limited and modified extent. The enormous and rapid accumulation of wounded thrown upon the Surgeon's hands after an action leaves him but little time for the adoption of these minute precautions that are necessary for the full success of the antiseptic method. But the condition of the soldier himself, and that of his surroundings, are equally unfavourable to the carrying out of the treatment in its completeness—in the manner, in fact, in which it is employed in civil hospitals. But yet experience has shown that it is better to employ it in a modified form than not at all. On this point all are agreed.

In the Russo-Turkish war of 1876–77, the Surgeons in the Russian army were desirous to adopt the antiseptic treatment as thoroughly as possible; and all speak favourably of it, even in the modified form in which alone it was practicable. Bergmann, according to Surgeon-Major Melladew, found it impossible to carry it out with anything like completeness at the crossing of the Danube, where the wounded were comparatively few. The river-water was full of sand and mud, which soon choked the spray-producers, and rendered them useless; and no amount of carbolic acid was sufficient to purify it so as to take away its foul smell. Then, again, the skin of the wounded soldier, begrimed with the dust and sweat of long marches and of battle, cannot be cleansed with the appliances usually at hand.

But yet, and notwithstanding all these drawbacks, the antiseptic treatment did more than had ever been effected with any other; for it was by its means that Bergmann and Reyher saved almost all their cases of gun-shot wound of the knee-joint. The fate of the soldier is truly, as Nussbaum has said, in the hands of the Surgeon who first attends him. If primary antiseptic treatment is at once used, he will have an infinitely better chance than by any other method.

The best mode of carrying out the antiseptic treatment in war is still undetermined, but at present chloride of zinc seems to be the most practically useful antiseptic agent for cleaning the skin and wounds, as it can be carried in the solid form and dissolved in water when required. The wound should immediately be well cleaned by being syringed out with the antiseptic lotion. Above all, the Surgeon must avoid that most pernicious practice of exploring the wound with a grimy finger or unclean probe, thus at once and with certainty infecting it to the very bottom. As a first dressing, all Surgeons are agreed that one of the forms of dry absorbent application, impregnated with a

powerful non-volatile antiseptic, is most likely to be successful. Salicylic cotton-wool, salicylic jute, and iodoform-wool, are the forms of dressing which seem most likely to be practically serviceable, and when applied they should be left undisturbed for as long a time as possible. Reyher, in the Russo-Turkish war of 1877, adopted two modes of dressing. If the apertures of the wound were very small, and no foreign bodies or splinters of bone required removal, he simply washed the skin externally with a 1 in 20 solution of carbolic acid, and applied a dry gauze dressing, which was left untouched, the wound being allowed if possible to heal by scabbing beneath it. If the apertures were large, and splinters of bone had to be removed, he carried out Lister's treatment with all its details, with injection of the wound, drainage, and repeated dressings. By both these modes of treatment he obtained a large proportion of success.

In order to limit the inflammation, it was in former times a common practice with military Surgeons, and still is so with the French, to enlarge by incision the wound made by the ball, with a view of providing a better exit for discharges and preventing tension. John Hunter, who regarded the inflammation and sloughing that occur in gun-shot wounds as dependent solely on the contused nature of the wound, maintained that this practice only superadded another injury to the one already inflicted by the bullet; and following his precepts, British Surgeons have employed the knife, in the early stages of gun-shot wounds, only for the purpose of facilitating the ligature of bleeding vessels, or the extraction of foreign bodies. In the more advanced stages, however, free incisions, which should be made in the direction of the axis of the limb, are commonly required in order to lessen inflammatory tension, to prevent the extension of sloughing, and to favour the escape of discharge.

At the present time, however, when the necessity of perfect drainage is so fully understood, it becomes a question whether it would not be better practice to enlarge the wound when it is evidently too small to give a perfectly free exit to the discharges. Such a line of practice undoubtedly facilitates the antiseptic treatment, as it renders the cleaning of the wound more easy, and for this reason it was adopted by Volkmann in the cases before alluded to.

If the Surgeon is unable to adopt any strictly antiseptic dressing, the best mode of lessening inflammation in a gun-shot wound in the early stages, and more especially in hot climates, is cold irrigation, or if possible the application of dry cold by means of ice in India-rubber bags, conjoined with drainage and rest. As suppuration comes on, we must substitute warm applications for the cold, so as to hasten the formation of matter and the separation of the sloughs, whilst disinfectants should be freely used to the whole cavity of the wound. All bagging and burrowing of matter must be carefully guarded against by position, pressure, drainage, and, if need be, a counter-opening. Free incisions may also now be required. These should not be delayed too long. They may be required for three purposes: first, to remove the tension resulting from deep infiltration of the limb by inflammatory effusions; secondly, to open up purulent collections, and give exit to the decomposing discharges, and thus to relieve the severe constitutional disturbance dependent upon the absorption of the chemical products of putrefaction; and thirdly, to extract splinters of bone, portions of clothing, and other foreign bodies that could not be removed in the first instance. When the inflammation

is very acute and will not yield to the measures just enumerated, it has been recommended to compress or to tie the main artery leading to the part. At the period of the loosening and separation of the sloughs, there is always especial danger of the supervention of consecutive hæmorrhage. The patient, consequently, at this time requires to be carefully watched : if the wound be in the vicinity of a large vessel, a tourniquet should be placed loosely round the limb, so as to be screwed up at a moment's notice ; and, on the supervention of bleeding, the artery must be ligatured, if possible, at the seat of the wound, or, if this be not practicable, in the most convenient situation above it ; and if this do not arrest the bleeding, recourse should be had to amputation.

Serious results, such as abscesses, profuse discharges, osteomyelitis, necrosis, and the separation of splinters of bone, must be subsequently looked for in many cases ; and these results may be prolonged for many years, at last perhaps wearing out the patient if the cause of irritation be not removed. Thus General Bem required to have a bullet removed by Liston from the external condyle of his femur, nineteen years after it first lodged there ; and Marshal Moncey died forty years after the receipt of a gun-shot wound, from its effects. A soldier who was wounded at the storming of the Redan died under my care in the University College Hospital, two years and a half after that event, of exhaustion resulting from a large lumbar abscess. On examination it was found that the bullet, which had entered the left side of the chest, wounded the lung, traversed the diaphragm, notched the spleen, passed between the kidney and suprarenal body, and perforated the spine, was lying encapsuled on the right side of one of the vertebræ, pressing upon the right renal vessels. Its irritation, and that of the sequestra from the injured spine, produced the abscess, from the effect of which the patient died.

The aperture of exit always heals sooner than the aperture of entry ; owing, probably, as Neudörfer observes, to the bullet having lost its lateral action in its passage through the tissues, and merely cutting its way out. It is at the point, he remarks, where the lateral action is lost, that healing begins.

II. **Amputation** is required in gun-shot injuries in two classes of cases of very dissimilar character.

In cases in which the limb has been wholly or in part carried away, or when it is evidently hopelessly shattered, the ragged, conical, and quivering stump, or the mangled remains of the limb, must be removed. In such cases there can be no doubt whatever in the mind of any Surgeon as to the necessity for immediate amputation.

But there is another class of cases, in which amputation is also very commonly required, though to a Surgeon judging solely from the accidents of civil life it might not at first appear necessary. These are, especially, cases of *compound gun-shot fractures of the thigh*, *bullet-wounds of the knee-joint*, and many similar injuries of the leg. Injuries such as these, occurring from other causes in civil practice, might admit of an attempt being made to save the limb. But in military practice it is different : here the attempt to save the limb with the means usually at the command of a Surgeon in actual warfare, may be followed by such extreme local and constitutional disturbance as to jeopardize seriously, and probably to destroy, the patient's life. In such circumstances, conservatism is often a fatal error ; to save life the limb must be sacrificed. The injury for which an experienced Army-Surgeon knows that amputation is

imperative may look but trifling, and to the patient himself, or to the civilian, may appear to justify treatment by less severe procedure ; but experience has so far incontestably shown that, under ordinary circumstances, amputation is almost the only chance of safety in gun-shot wounds of the lower third of the thigh and of the leg, fracturing the bones, or injuring the knee-joint. Dupuytren states that, in rejecting amputation in compound fractures of the extremities from gun-shot, we lose more lives than we save limbs ; and Hennen is of opinion that in all "ambiguous cases" amputation should be performed. We have still to learn how far the use of antiseptics will enable us to modify these rules ; but it is scarcely possible that the military Surgeon of the future will always have the necessary materials at his command for strict antiseptic treatment, and consequently he must frequently be guided in his practice by the experience of former times, and resort to amputation in cases in which under more favourable conditions there might be a fair prospect of saving the limb.

The following is a specification of the chief conditions in which amputation is required.

1. When the whole limb is carried off, a ragged stump merely being left ; so, likewise, if the limb be completely crushed and disorganized though still left adherent ; or again, if the principal vessels be injured and the soft parts carried away, though the bone be intact, the limb cannot be preserved.

2. Amputation is especially necessary in some of the more serious injuries of the lower extremity ; thus, if a bullet divide the femoral vessels or the sciatic nerve, and splinter the thigh-bone ; or if the sciatic nerve and soft parts at the back of the thigh be carried away, although the vessels and bone be left uninjured, the case is one for amputation. It may be stated generally (though, doubtless, there are exceptions to this, as to all general rules in surgery) that in the case of a *compound fracture of the lower third of the femur* occasioned by gun-shot, amputation is the safer practice, unless the patient is likely to be placed in exceptionally favourable circumstances after the wound, and the Surgeon has at his command all the means necessary for efficient antiseptic treatment.

The mortality, however, after amputation for gun-shot injury of the *upper two-thirds of the thigh* is so very great, that many Surgeons have abandoned the operation in these cases, and professional opinion is unsettled as to the course that should be pursued. In the Schleswig-Holstein war of 1849, it became a question with many of the German and Danish Surgeons whether this operation should be continued, or whether the patient would not have a better chance if the injury was treated on ordinary principles as a compound fracture. At the siege of Sebastopol, the mortality after amputation in the upper third of the thigh was so great in the Russian army, that the Surgeons abandoned the operation. On the other hand, it is stated in the Report of the Black Sea Fleet, that to attempt to save the limb in any case of gun-shot fracture of the thigh was to endanger the patient's life. In the Crimea, Macleod states, that a bad compound fracture of the thigh from gun-shot was synonymous with death. This was partly owing to the bad health of the troops, and partly to the terrible effects of conical balls. In India, where round bullets and matchlock-balls were more used, the result was not so bad.

Macleod states that, although he made every inquiry, he could hear of three cases only in which recovery had, in the Crimea, followed a compound fracture

of the upper third of the thigh-bone without amputation. But, exceptional as were such recoveries, he states that they were not so rare as after amputation for similar injuries ; as indeed was proved by the fact that not one patient recovered after amputation at the hip-joint. Hutin, the Surgeon to the Invalides in Paris, was able to discover twenty-four cases of recovery after compound fracture above the middle of the thigh, but no case of recovery after amputation for injury of the same part. In the British army in the Crimea, the amputations in the upper third of the thigh, which must have been for compound fractures low down in the bone, were fatal, in the ratio of 86 per cent. ; of those in the middle, probably for injuries of the lower articular end and knee, 60 per cent. died ; whilst of those in the lower third, which must have been for injuries of the knee and leg, the mortality was reduced to 56 per cent. The conclusions at which Macleod arrives, after a careful inquiry into this question, are so important, that I give them in his own words. He says : "Under circumstances of war similar to those which occurred in the East, we ought to try to save compound comminuted fractures of the thigh when situated in the upper third ; but immediate amputation should be had recourse to in the case of a like accident occurring in the middle and lower thirds." In the great civil war in America, the opinions of Surgeons appear to have been divided ; and the conclusion arrived at seems to have been that, provided the large vessels and nerves were not injured, and the circumstances in which the patient was placed as to conveyance not too unfavourable, the chance of recovery would be equal whether amputation were performed or an attempt made to save the limb. But even in these circumstances Hamilton states that, although his experience in that great war has led him to the conclusion that in the upper third the life is least hazarded by an attempt to save the limb, in the middle third conservatism and amputation afford an equal chance, whilst in the lower third of the thigh the chances are in favour of amputation. This is a conclusion very similar to that arrived at by British Surgeons.

When an attempt is made to save the limb, the skin should be cleaned on the field of battle, if possible, with some strong antiseptic, and the limb enveloped in a large mass of salicylic wool, over which a plaster-of-Paris bandage should be applied. This dressing may be left untouched, unless some special circumstances require its removal, for some days, until the patient reaches the hospital in which the further treatment is to be carried out. In some rare cases healing will take place under a dry scab. If at the end of four days the patient is suffering no pain and is free from fever this fortunate result may be looked for ; in other cases the primary dressing should be removed about that time, and during the further progress the case must be treated by extension and counter-extension, the free use of antiseptics, and the limb may be securely fixed in a plaster-of-Paris apparatus with a window opposite the wound.

3. In gun-shot fractures of the *bones of the leg*, amputation becomes necessary if the tibial arteries be injured, or if the knee or ankle-joint be badly wounded. If the injury be in the middle of the leg, at a distance from these joints, and provided there be not longitudinal fissuring of the bone leading into them, much may be done to save the limb, by the extraction of splinters, and the removal of sharp and angular fragments of bone, the limb being put up in the plaster-of-Paris apparatus. In such cases, the patient may recover with a shortened but otherwise useful limb.

4. Gun-shot wounds of the *foot*, if perforating and splintering the tarsus, require amputation, either at or above the ankle. Those of the *hand* are of special interest from their frequency, in consequence of the bursting of guns, or of powder-flask explosions. In these cases, however extensive the injury may be that is inflicted upon the hand, fingers being blown away, the thumb thrown back, and the metacarpal bones splintered, we must endeavour, if possible, to save a portion of it, if it be only one or two fingers; and, owing to the great reparative power possessed by the hand, we shall often, in the worst-looking cases, be able to accomplish this. If the thumb, with one finger as an opponent, can be preserved, it will be of more service to the patient than any artificial contrivance, however ingeniously made.

5. It not unfrequently happens that amputation may be required in the more advanced stages of gun-shot injury, in consequence of mortification. In these circumstances, it must be practised without delay, and without waiting for the line of separation. If, in consequence of long-continued suffering and discharge, the patient's health becomes greatly deteriorated, and the limb remain an useless appendage, amputation will at last be imperative.

6. Gun-shot injuries of *joints* are necessarily most serious and fatal—the danger depending on the size and complexity of the articulation, rather than on the extent of the injury. Wounds of any of the three large joints of the lower extremity are especially dangerous and fatal; those of the upper extremity are more readily, and indeed commonly, recovered from. The fact of a joint being wounded is generally obvious enough from the direction taken by the ball, the comminution of the bones, and perhaps the escape of synovia; but a joint may be fatally injured by the longitudinal splitting of the bone into it, although the bullet has not passed within some inches of it.

In bullet-wounds of joints, excision may be advantageously substituted for amputation in cases in which the soft parts are not too extensively torn, the large nerves and vessels are uninjured, and the shaft of the bone not too widely splintered, the mischief being confined chiefly to the articular ends.

Bullet-wounds of the *head*, *neck*, or *trochanters of the femur*, *splintering the bone into the articulation*, are necessarily most serious. If they be left to palliative treatment, the death of the patient may be considered as almost inevitable; if amputation at the hip be performed, the prospect is better; and, though desperate, the case must not be considered as hopeless. This is well illustrated by the result of amputations in the great war of the American Rebellion (p. 105). In *Primary* amputations at the hip-joint for gun-shot injury, the mortality was, according to one estimate, 94, according to another, and I think more correct, 84 per cent. All *Intermediate* amputations were fatal; the *Secondary* ones only at the rate of 77 per cent. If the shaft be not too much implicated, it is probable that the best hope lies in the excision of the splintered head of the bone, and the careful removal of the loose fragments. This operation, originally proposed by Guthrie, and first successfully performed by O'Leary in the Crimean war, presents the most reasonable, though but a slender, hope of safety to the patient, and should accordingly be practised. With this view the wound must be laid freely open, loose fragments extracted, and the upper end of the bone detached, turned out, and sawn off. Of six cases in which this was done in the Crimea, one patient, O'Leary's, recovered. Gurlt, who has collected all the cases of excision of joints for gun-shot

wounds which have been recorded since 1792, states that excision of the hip has been performed 139 times; 16 of the patients recovered, 122 died, and the result of the remaining case is uncertain.

Bullet-wounds of the *knee-joint* are among the most serious injuries in surgery; and this whether the bones be much comminuted or not, provided the epiphysis of the tibia or femur be perforated, or the articulation be fairly traversed or even penetrated by the ball. Prior to the American war there were but seven cases in which excision of the knee had been done for gun-shot injury—five in military, two in civil practice; the two latter cases recovered, the other five died. In the American war the operation was done eleven times: in two cases, one primary, the other secondary, recovery took place; nine deaths resulted, chiefly from pyæmia. In three cases in which the patella alone was excised, death ensued. Gurlt has collected the records of 146 cases, of which 33 recovered, 111 died, and the result was uncertain in the remaining cases. These results are so bad that the operation for the future will probably be abandoned in military surgery. It is in this class of cases, however, that Bergmann and Reyher have obtained a very considerable measure of success by conservative treatment, with strict antiseptic dressing. Bergmann had 15 fresh gun-shot wounds of the knee under his care after one of the battles in the Russo-Turkish war. These were all treated by superficial cleaning of the skin with carbolic lotion and the application of a mass of salicylic wool, especially thick at the knee, secured by an elastic bandage and covered with a plaster-of-Paris apparatus. They were then immediately sent on a four days' journey, under great difficulties from roads and weather, to the hospital at the base of operations. Of these 8 recovered without suppuration, 2 suppurated slightly and 5 severely. Of these five, two recovered without amputation, two after amputation, and one died of pyæmia. Reyher, by the employment of carbolic gauze, either as a permanent dressing to obtain healing by scabbing, or with drainage, obtained the following results. In 18 cases which came under his care before they had been probed or examined he got union of the wound under the dry dressing, without suppuration, in 10; in 6 he treated the wound by antiseptic drainage and of these 3 died; and in 2 drainage was commenced at a later period of the case and both recovered. Thus in the 18 cases treated primarily by antiseptic dressing, 3 died, and all the survivors preserved the limb with a considerable degree of mobility in the joint. Forty cases which had been "fingered" before he saw them also came under his observation. Of these 19 were treated by drainage after occlusion had failed and 18 died; in 9 more intermediate amputation was performed, with 7 deaths; in 12 secondary amputation was performed, and with 9 deaths; making a total of 40 cases, with 34 deaths, and only one limb saved. Conservative treatment was attempted without antiseptic dressing in 23 cases, and of these only one finally recovered, and in his case healing took place by scabbing under a dry dressing.

In all cases *in which antiseptic treatment is impossible,* and these will probably form a large proportion of all gun-shot wounds occurring during actual war, conservative treatment contrasts most unfavourably with primary amputation in the lower third of the thigh. When amputation is determined on, the operation requires to be performed early, not because the apparent injury may be very severe, or the mutilation of the limb so great as obviously and imperatively to call for immediate amputation, but because experience

has shown that, unless the limb be removed at an early period, after-consequences of the most serious and fatal character will to a certainty ensue. Extensive suppuration of the joint, deep and large abscesses burrowing among the muscles of the thigh, and consequent exhaustion of the patient by hectic, or his destruction by pyæmia, are the conditions that amputation alone, performed at an early stage, can avert. This necessity for early amputation in penetrating bullet-wounds of the knee-joint, when antiseptic treatment is impossible, is recognized by all modern military Surgeons. Guthrie and Larrey in the French wars, Esmarch and Stromeyer in the Schleswig-Holstein campaign, and the Surgeons in the Crimea, all found that the attempt to save a limb so injured led to the sacrifice of the patient's life.

Bullet-wounds of the *ankle-joint* do not necessarily require amputation. If the bones be not too extensively comminuted, and more particularly if the posterior tibial artery and nerve have escaped injury, an attempt, and probably a successful one, may be made to save the limb; the injury being treated on those principles which will be described in the chapters on Fractures and on Dislocations. In such cases extraction of fragments, and excision of the splintered ends, are necessary; and modified operations, partial excision by means of gouge, forceps, and Hey's saw, will be found more successful than the more systematic operations. Gurlt has collected 150 cases of excision of the ankle, with 94 recoveries, 51 or 33·92 per cent. deaths, and 5 uncertain. If the large vessels and nerves have been cut across, and the bones very extensively shattered, amputation will be the proper course to pursue.

Fig. 119.—Spherical Bullet in Head of Humerus.

The *shoulder*, and more particularly the left shoulder, from its advanced position in the act of firing, is peculiarly liable to gun-shot injury; the bullet either lodging in the head of the humerus or traversing it, and perhaps fracturing some of the bony processes of the scapula in its immediate vicinity; or, as in the case of common shot, or fragments of shells, carrying away the fleshy cushion of the deltoid muscle. It is especially in bullet-wounds of the shoulder and elbow-joint, that conservative surgery has been most successful. In such cases, when the bones are penetrated, and even shattered by a bullet, provided the main blood-vessels and nerves of the limb be not injured, amputation will seldom be required; and, indeed, it should be laid down as a rule in surgery, that excision should be preferred to amputation in all cases in which the large blood-vessels and nerves are not wounded, or the soft parts too extensively disorganized. The wound having been enlarged, loose spicula must be removed, and the splintered and jagged ends of the fractured bone sawn smoothly off. If the bullet be still lodged in the head of the humerus, as in Fig. 119, the same course should be adopted. It has been a question with Surgeons whether excision or amputation should be done when the upper end of the shaft of the humerus has been much splintered, with or without penetration of the joint. In these cases the epiphysis is often uninjured. Guthrie advised amputation; but the result of the experience of the war in America has been that five or six inches of the shaft of the humerus may be removed with perfect safety, and that no good comes of leaving the uninjured head, which should also be excised. The results of excision of the joints of the upper extremity are in the highest degree satisfactory. Thus

Baudens states that he saved 13 out of 14 cases of excision of the shoulder. According to Thornton, in the British army in the Crimea, the shoulder was excised 12 times with 2 deaths; the elbow in 17 cases, of which two were fatal; and partially in five other cases, all of which were successful. These results, which reflect the highest credit on the skill of our Army-Surgeons, were more successful than those that followed amputation of the corresponding parts. Of 60 disarticulations at the shoulder, 19, or 31 per cent., were fatal; and of 153 amputations of the arm, 29, or 19 per cent., died. The result of resection of these joints has not been quite so satisfactory elsewhere: thus, in the Confederate army in America, Chisholm states that up to February, 1864, of 59 cases of excision of the shoulder, 20 proved unsuccessful; and of 45 cases in which the elbow was excised, 9 were unsuccessful. In the

Fig. 120.

Fig. 121.—Result of Excision of Head and six inches of Shaft of Humerus shown in Fig. 120. (U. S. Army Med Dep.)

official report of the Surgeon-General of the United States army, of 286 cases of excision of the elbow in which the results are known, it is stated that 62 died, and that in 16 amputation became necessary. Of 210 primary excisions of the shoulder-joint death occurred in 50; and in 298 secondary excisions 115 cases were fatal, giving a mean mortality of 32·48, against 39·44 for amputation at the shoulder, and 44·4 for cases treated on the expectant plan. In the Russian army, conservative surgery was also extensively practised; and in it, according to Mouat and Wyatt's report, of 20 cases of excision of the elbow, 15 recovered.

Gurlt has collected 1,661 cases of excision of the shoulder in military surgery with 1,067 recoveries, 567, or 34·7 per cent., deaths, and 27 uncertain; and 1,438 of excision of the elbow, with 1,054 recoveries, 349, or 24·87 per cent., deaths, and 35 doubtful.

The operation of excision of large portions of the shaft of the humerus, as well as of its head, was carried much further by the American military

Surgeons in the war of the Rebellion than had heretofore been done. Fig. 120, taken from photographs in the possession of the Army Medical Department at Washington, represents six inches of the shaft of the humerus with its head, which had been thus excised; and Fig. 121, the arm that was left. I saw the man, who is an orderly in that splendid and unrivalled collection, the Army Medical Museum at Washington, and I can testify to the utility of his arm; the bone so skilfully taken away he himself exhibited.

Excision of the wrist, in whole or in part, for gun-shot injury has not proved very satisfactory, not so much from death as from inutility of the hand that was left. Of 27 done in the American war, only 3 died. In two instances, amputation of the fore-arm was practised.

Gurlt has collected 133 cases with 112 recoveries, 20, or 15·15 per cent. deaths, and 1 uncertain.

The steps of all the excision-operations are the same, whether the excision of the part be required for gun-shot injury, or for other accidents, or for disease; except that in gun-shot injury advantage may often be taken of the wound in the soft parts, by enlarging which longitudinally, the shattered bone may be readily reached and extracted, and the splintered ends sawn smooth.

The question as to the *period at which amputation ought to be performed* after the infliction of gun-shot wounds is one of great importance, and has given rise to much discussion among Surgeons. The older military Surgeons, Paré, Wiseman, Ledran, Ranby, &c., taking a common-sense view of the question, advocated the removal of the hopelessly injured limb as soon as possible after the receipt of the injury. Wiseman's advice is to "cut off the limb quickly, while the soldier is heated and in mettle;" and this advice has not been and cannot be improved upon. After the battle of Fontenoy, in the middle of the last century, professional opinion underwent a change upon this subject; and Faure wrote a thesis, which obtained a prize of the French Academy of Surgery, recommending delay in amputating in certain cases. Hunter, Percy, and other Surgeons of repute, promulgated similar views; and Bilguer, the Surgeon-in-chief to the armies of Frederick the Great, went to the absurd and dangerous extent of condemning amputation entirely. These extreme opinions necessarily occasioned a reaction; and the experience gained in the wars of the French Revolution and of the Empire has enabled Surgeons to settle this question definitely. It is more particularly through the labours and observations of John Bell, Larrey, Thomson, Guthrie, S. Cooper, and Hennen, that the necessity of having recourse to immediate amputation in all cases of gun-shot injury requiring this operation has been fully recognized, and the truth of Wiseman's advice has been re-established.

In determining this point we must be guided, partly by surgical experience of the result of such cases when left to nature, and partly by an appeal to facts. In appealing to experience we must, to use the forcible language of Sir Charles Bell, contemplate what will be the condition of the parts in twelve hours, in six days, and in three months. "In twelve hours the inflammation, pain, and tension of the whole limb, the inflamed countenance, the brilliant eye, the sleepless and restless condition, declare the impression the injury is making on the limb and on the constitutional powers. In six days, the limb from the groin to the toe, or from the shoulder to the finger, is swollen to half the size of the body; a violent phlegmonous inflammation pervades the whole; serous

effusion has taken place in the whole limb; and abscesses are forming in the great beds of cellular texture throughout the whole extent of the extremity. In three months, if the patient have laboured through the agony, the bones are carious; the abscesses are interminable sinuses; the limb is undermined and everywhere unsound; and the constitutional strength ebbs to the lowest degree."

If we appeal to facts, we shall find that of 300 secondary amputations reported by Faure, after the battle of Fontenoy, only thirty were successful; whereas Larrey saved three-fourths of his primary amputations in the Napoleonic wars. In the Peninsular war, the comparative loss after secondary amputations of the upper extremity was, to that following the primary, as twelve to one; and of the lower extremity, the loss after secondary amputation was three times as great as after primary. During the siege of Sebastopol, among 80,000 wounded Russians there were 3,000 amputations. Of the primary amputations of the upper extremity, leg, and foot, about one-half, and of the lower and middle third of the thigh, about one-third recovered; but of all the secondary amputations more than two-thirds died. Primary amputation, therefore, should always, when practicable, be performed in preference to secondary.

But how soon after the infliction of the injury should it be practised? It is the opinion of some Surgeons that there is often an interval between the infliction of the injury and the supervention of the shock to the system, in which the limb may more advantageously be removed. Should the depression of "shock" have come on, it then becomes a question whether immediate amputation should be practised, or the removal of the limb delayed until reaction sets in. On this point it is obviously difficult to lay down any very definite rule; but it may, I think, be stated generally as the result of the experience of the best Army-Surgeons, that, if the shock be not very intense, the limb may, under chloroform, be safely removed. Should the prostration be excessive, and there be reason to fear the possibility of internal injury, it will be wiser to delay operation. But if an unsuccessful attempt at the preservation of the limb be made, and if occasion for its subsequent removal should arise, the Surgeon must wait until suppuration has set in before he operates, the period of acute inflammation and septic fever being allowed to pass by. The most favourable time is usually about the tenth day. Among the cases that require secondary amputation are any in which traumatic gangrene may happen to set in; here the limb must always be removed without delay. If profuse hæmorrhage from the wound occur, and do not admit of suppression by the ordinary means, secondary amputation may become necessary. So, also, when the bones do not unite, the patient being worn out by discharges and the irritation of necrosis and caries, and left with a wasted, shattered, and useless limb, its removal is the only means of saving life. The great mortality after secondary amputation in military practice is, in great measure, owing to the unfavourable hygienic conditions to which the wounded soldier is usually exposed from over-crowding and want of necessary appliances. He is thus rendered peculiarly liable to the occurrence of pyæmia, septicæmia, and hospital gangrene.

The nature and treatment of gun-shot injuries of special regions, as of the head, chest, and abdomen, will be considered in the Chapters devoted to the description of Injuries of those parts.

CHAPTER XI.

POISONED WOUNDS.

A VERY important variety of wound is that in which a poison is introduced. The poisons that can be thus inoculated belong to two great classes; first, the non-infective, which have no power of increasing in quantity in the living body, and, secondly, those which possess true infective properties and multiply amongst the tissues or in the blood. In the former class the effect is proportional to the dose, in the latter it is not; in the former the effect begins to manifest itself immediately, in the latter there is sometimes a period of incubation, during which no symptoms indicate the presence of the poison. Both classes may act locally or generally. When the non-infective poisons produce grave general symptoms, it is due either to the quantity introduced or to the intensity of the virus. The most important of the non-infective poisons are the venom of various insects, the poison of snakes, and the chemical products of putrefaction. Amongst the most important of the true infective poisons are the virus of rabid animals, of glanders, of malignant pustule, and of certain unhealthy processes in the living human body.

STINGS OF INSECTS.

Stings of Insects, as of bees, wasps, mosquitoes, gnats, &c., though painful, seldom produce any serious inconvenience; yet occasionally they may do so, and may even prove fatal, by serving as a starting point for erysipelas in some unhealthy constitutions, or by giving rise to intense irritation from the multiplicity of the stings, as when bees in great numbers swarm upon and sting a person; or they may be dangerous in consequence of the nature of the part that is stung, as the eye, or the interior of the mouth, or pharynx, as has happened from swallowing a bee in a piece of honeycomb. Mosquito-bites are peculiarly irritating, and, when numerous, poison the blood, producing nervous depression and great febrile irritation. The venom of a mosquito is very powerful, weight for weight probably more so than that of the rattlesnake. The bites of some insects, as scorpions, or the tarantula in Italy, give rise to more serious and even fatal disturbance. A peculiar train of nervous phenomena is said to follow the bite of the tarantula, hence called "tarantismus;" a disease that is generally stated to be peculiarly influenced by music, though this has been denied by Gozzo.

TREATMENT.—In the treatment of stings of insects the application of cooling lotions or of a cold poultice, or rubbing the part with olive-oil, will be found the most useful means of allaying irritation. In some cases, more especially in mosquito-bites, or the stings of bees or wasps, touching the part stung with strong liquor ammoniæ or potassæ gives relief, if applied at once. In the case of stings from wasps or bees, it should be ascertained that the sting has not been left in the wound. If so, it must be extracted, and the alkali applied.

SNAKE-BITES.

Snake-bites are seldom fatal in England, the viper or adder not possessing a sufficiently energetic poison to destroy a healthy adult, though it might possibly kill a child or a very weak and delicate person. Snakes are said to be most actively venomous in warm weather and during the season of procreation. Their bites are of course most dangerous if inflicted through a vein or glandular part, or near the centre of the circulation, or about the neck and face. In tropical countries the bite of the rattle-snake, of the cobra di capello, the puff-adder, or the tobacco-pipe snake, is often fatal. The number of persons who are annually killed by snake-bites in those parts of India alone from which returns are procurable amounts to about 12,000, or about 1 in every 5,000 of the inhabitants; and it occasionally happens even in this country that the Surgeon has an opportunity of seeing wounds inflicted by these fearful reptiles in menageries. Thus, Sir E. Home has recorded a fatal case of rattle-snake bite occurring in England. A similar instance has been seen at St. George's Hospital, and another in Paris, in showmen. The most remarkable case of this kind with which I am acquainted occurred some years ago at the University College Hospital, and afforded an opportunity, rare in this country, of witnessing the effects of the bite of a cobra di capello. The patient, a keeper at the Zoological Gardens, was bitten in the bridge of the nose, the poison-fang having apparently penetrated the angular vein. When brought to the hospital, about half an hour after the accident, he was apparently dying, being unable to speak, swallow, or support himself; the pupils were dilated, the face livid, the heart's action feeble, and he was scarcely conscious. After death, which took place in little more than an hour from the time of the infliction of the wound, the veins of the brain and the cerebral sinuses were found congested with blood, as were also the lungs to an immense extent, and the solid abdominal viscera. The right cavities of the heart were loaded with dark blood, the left being empty; indeed, the phenomena of asphyxia were strikingly marked. In this case, death would appear to have resulted from the poison paralysing the medulla oblongata, and those portions of the nervous system which are concerned in carrying on respiration, at the same time that the blood was disorganized by the action of the virus.

Effects of Snake-poison.—The venom of the cobra has been found to consist of an albuminous fluid of neutral reaction, holding cells in suspension. It is said to contain also a non-organized ferment resembling ptyaline. The poison is secreted by a gland communicating by a duct with the hollow fang, and so situated that in the act of biting it is compressed by the muscles of the jaw and the venom is thus forcibly ejected from the fang. When given internally, or applied to the conjunctiva, it fails to kill. Snake-poison, when introduced into the system through a bite or puncture, may prove injurious or kill, either by its primary and direct depressing influence on the nervous system, somewhat resembling that produced by some narcotic poisons; or, secondarily, and more remotely, by exciting severe diffuse inflammation of the areolar tissue of the limb or part. The intensity of its effects depends upon the quantity injected, and consequently upon the size and vigour of the animal inflicting the wound; one that has been compelled to bite frequently has no longer the destructive power which it had when fresh.

The first mode of death occurs only when the poison is either very powerful, or the animal bitten small. Thus the poison of the tobacco-pipe snake is said

to be so virulent, that it will kill a full-grown man in less than a quarter of an hour. The rattle-snake, and the cobra di capello, will kill a small animal in the course of a few seconds ; and a man, bitten some years ago by a rattle-snake in Paris, died in nine hours ; the cobra-bite just related was fatal in little more than one hour ; the Australian tiger-snake will kill in less than twenty-four hours.

When the snake is less venomous and death is not speedy, the poison excites diffuse inflammation and suppuration of the areolar tissue of the limb bitten. This is a very common consequence of the bite of the viper in this country. It may occur also after bites by the larger ophidia. Thus, in the case which occurred in St. George's Hospital, the patient died on the eighteenth day after the bite of the rattle-snake, with large abscesses in the arm and in the axilla, and with sloughing of the areolar tissue of the limb.

The SYMPTOMS occurring after a poisonous snake-bite consist in great depression and prostration of the system, a feeble and intermittent pulse, dilated pupils, usually slight delirium, indistinctness of speech, at times complete aphasia, speedy stupor, insensibility and death. The pain is burning and lancinating, whilst the part bitten swells and becomes livid in a few hours; and if the patient survive sufficiently long, diffuse inflammation and gangrene occur in its neighbourhood ; involuntary evacuations take place ; the depression increases and may eventually terminate fatally, or end slowly, and after a lapse of time, in the recovery of the patient, whose health may long suffer seriously from the effects of the accident.

TREATMENT.—This is local and general.

The **Local Treatment** can be fulfilled with success only when the patient is seen immediately after the accident, as the absorption of the poison is very rapid. It presents two great indications ; 1, to prevent the absorption of the poison into the system : and 2, to treat the diffuse inflammation and sloughing that may subsequently occur. The first indication may be fulfilled by tying a ligature so tightly round the limb at a little distance above the injured part, as to arrest all circulation through it. In this way the absorption of the poison may be prevented ; the wound should then be freely cauterized with a red-hot iron or cinder, or better still, excised, and a cupping-glass applied over the cut surface, so as to withdraw the blood in the neighbourhood which may have become contaminated by the poison. If a cupping-glass be not at hand, or if the part bitten be so situated as not to admit of its application, there can be no objection to the employment of suction by the mouth after free excision ; the poison not being absorbed by an unbroken mucous membrane. In using suction, the mouth should be rinsed with brandy. A plan sometimes adopted when the bite is inflicted while shooting in India is to pinch the part up and cut it out at once and then to make a paste in the wound with blood and gun-powder and light it, by which the raw surface is effectually cauterized. With the view of lessening the swelling, tension, and pain of the limb, frictions with olive oil are said to be advantageous. After diffuse inflammation has set in, this must be treated on general principles—by fomentations and free incision.

The **Constitutional Treatment** consists in the early and free administration of the most powerful stimulants, with the view of combating the depression that exists. For this purpose brandy, wine, ammonia, or ether must be freely given. The *eau de luce*—which enjoys a high reputation in some tropical countries—owes its efficacy to the ammonia which it contains. Should drowsi-

ness come on, the patient must be made to walk about; and artificial respiration with galvanism may be resorted to as a last means of maintaining life until the effects of the stimulants may overcome those of the poison. Enforced exercise —the patient being made to run for some distance behind a carriage driven at a steady pace—is another means of keeping up the respiration, while the sweating aids in the elimination of the poison. Large doses of arsenic have been recommended as a kind of specific, and the "Tanjore pill," a celebrated Indian remedy, owes its activity to this mineral; but care must, of course, be taken in administering this, lest the remedy prove as fatal as the injury for which it is administered. Halford, of Melbourne, has used, in cases of bite by the "brown snake," a very venomous kind, whose bite is nearly always fatal, an injection of strong solution of ammonia, diluted with twice its bulk of water, into a superficial vein, such as the radial. Fifteen or thirty minims are thrown in, and repeated according to circumstances. The effect is described as immediate rousing of the patient from his stupor. Sir Joseph Fayrer, however, finds that this remedy has no power in cases of cobra-bite, or as an antidote to the poison of Indian serpents, whatever its efficacy may be in counteracting the deadly effects of those of the Australian species. As liquor potassæ decomposes the virus into a sediment and supernatant fluid, both of which are innocuous, it might be supposed that it would act as a true antidote; but it has not been found to do so when injected into the blood of bitten animals.

Difficulty with respect to antidotes for snake-poisoning appears to exist as much in their application as in their discovery. The venom of a snake is at once injected into the blood of the animal bitten, is carried with the circulation to the nervous centres, decomposing the fluid that conveys it, so that it has the start of any antidote that can possibly be applied to prevent its direct toxic effects on the system. It is difficult to understand how an antidote could act unless it were injected into the veins simultaneously with the introduction of the snake-poison into the blood. Unless a surgeon be at hand prepared to do this at the moment, as in the case of an animal bitten for experiment, the time lost would probably render the counteraction of the poison impossible. It is evident that drugs or substances swallowed with the view of acting as antidotes could not be absorbed from the stomach in time to be efficacious.

There is indeed nothing to be done but to endeavour to keep the patient alive, by the administration of stimulants, until the toxic effects of the poison wear off.

BITES OF RABID ANIMALS: HYDROPHOBIA.

Bites of rabid animals give rise to the disease so much and so justly dreaded, but fortunately seldom seen in man in this country, **Hydrophobia.**

This disease cannot originate *de novo* in man, but occurs in him invariably, and in the lower animals most commonly, as the result of inoculation. Animals of the canine and feline species are most subject to it; especially the dog, the wolf, the fox, the jackal, and the cat. The horse, ass, cow, or pig may be affected with it by inoculation from the bite of a rabid animal. It has not, I believe, been observed in lions or tigers, or in the larger feline animals. Does rabies ever originate *de novo* in animals? Sir Thomas Watson says not; most veterinary surgeons are of opinion that it does not, but is invariably the result of inoculation. If it ever does arise spontaneously, its causes are very

obscure. But it certainly appears to be subject to epidemic variations. In some years hydrophobia is never heard of—in others it is very rife. Hydrophobia has followed the bite of an animal that has shown no signs of rabies—one of those many inexplicable occurrences in this singular disease. It has been attributed to the influence of season, being most common in the early spring months; thus Eckel found it most common in dogs in February and May. Want of water, sudden changes from heat to cold, bad food, and unsatisfied sexual desire, have also each been assigned as the cause of its occurrence in animals. When we inquire into the operation of these alleged causes, we fail to discover any direct and positive connection between any one of them and rabies. With regard to the influence of heat and want of water, it would appear that in those countries in which animals of the canine and feline races are most exposed to these conditions, hydrophobia is unknown. Thus Mr. Donovan, who has resided and travelled for many years in Central Africa, informs me that, in the deserts of that country, where water is so scarce that man and beast often die of thirst, lions are always to be found and are occasionally seen going about in families, whilst hyænas, jackals, and wild dogs are most numerous, and yet hydrophobia is unknown. Barrow, a scientific and observant traveller, makes a similar statement, viz., that hydrophobia cannot proceed from thirst and heat, as it is unknown in Egypt, the West India Islands, and some other tropical parts. The theory of hydrophobia arising from ungratified sexual desire appears to be equally untenable. It is not uncommon in Africa, Mr. Donovan says, for wolves, jackals, and wild dogs to prowl about mad with heat; and in this state they are most dangerous, so much so that domesticated dogs instinctively shun them, but there is no evidence of their ever having communicated hydrophobia. Having been told that no bitches were allowed in Sark, I wrote to Dr. Cockridge of that Island to inquire if this were the fact, and if so, whether hydrophobia were prevalent there. He informed me that there were no bitches in the island, and that dogs were very numerous, but that no case of hydrophobia had, to his knowledge, ever occurred there, and that the clergyman, who had had thirty years' experience of the island, had never heard of a case of that disease. Dogs more frequently become rabid than bitches; thus, of a hundred and forty-one cases collected by Eckel, only fifteen occurred in bitches; and amongst dogs it is most common in those of a mongrel breed, seldom affecting those that are of pure blood, or that have been castrated.

In man, hydrophobia occurs either from the bite of a dog known to be rabid, or from a raw surface, as a crack in the lip, being licked by an animal ill of the rabies, but in whom the characteristic symptoms have not developed themselves. But it is important to know that the bite of a rabid animal is by no means certain to occasion hydrophobia; in fact, the vast majority of people who are bitten by animals in a state of rabies do not take the disease. Thus Hunter and Vaughan (Halford) state that only one out of twenty or thirty who are bitten by rabid dogs becomes hydrophobic. But the bite of a rabid wolf is far more dangerous than that of a mad dog. Watson states that of 114 persons bitten by rabid wolves, 67 died of hydrophobia. The bite of a rabid cat is also more dangerous than that of a dog. The fact is that the dog usually bites at the legs, and thus when he inflicts a wound, it is through clothing, by which his teeth are wiped and the saliva arrested, and thus the wound escapes inoculation. Wolves and cats, on the other hand, always fly

at naked parts of the body, as the face or throat; hence the greater danger of their bites. There is this important difference between the poisonous impregnation of the wound by the bite of a rabid dog and of a snake. In the case of the dog the poison is only adherent to the tooth, and hence, if this be wiped in its passage through clothing, the bite is rendered innocuous. In the case of the snake, the poison is projected through the hollow fang, and hence, wherever that enters, however cleanly its exterior may be wiped, this drop of poison is injected into the parts at the extreme point of penetration. A snake that bites through a gaiter or glove, would, therefore, inflict as deadly a wound as if the unprotected foot or hand were struck by the fang; whereas the tooth of the rabid dog would be wiped, and the bite be harmless. But making all allowance for the mechanical action of clothing in preventing inoculation of the part bitten, there is, I think, good reason to believe that there is a great difference in the susceptibility of different individuals to the poison of rabies. For it is an undoubted fact that veterinary Surgeons and others have often been bitten on an uncovered hand by rabid dogs, and yet have escaped the disease. Elliotson mentions the cases of two sisters who were both bitten in the face by the same rabid dog; the first escaped—the second died of hydrophobia. White, of Brighton, disbelieving in the contagion of the disease, inoculated himself with the saliva of a rabid dog with impunity.

It is not only the saliva and mucus of the mouth that is infective. Pasteur has shown that the blood and the substance of organs, as of the brain and medulla oblongata, when inoculated produce the disease.

Rabies differs from most other specific diseases in the length of time that the poison may lie dormant without giving rise to any symptoms. This period is very variously estimated by different writers. It is now generally believed to extend only to a few weeks. Elliotson says that the average time that elapses between the injury and the symptoms is from six weeks to three months. In the case of the Duke of Richmond, who was bitten whilst separating a tame fox and a dog that were quarrelling, (it is doubtful by which animal the bite was inflicted) the disease did not develop itself until between six and seven weeks after the injury. Meade has related the case of a lady who had the disease fifteen months after the bite; and Mayer of St. Petersburg that of a young man who died of hydrophobia twenty-six months after being bitten; Sir Thomas Watson adduces evidence that the poison may lie dormant for years. Writers, however, who state that six, seven, twelve, and even fifteen years have intervened between the infliction of the wound and the manifestation of the symptoms, have evidently committed an exaggeration or fallen into error, having probably confounded with hydrophobia other nervous affections that closely resemble it. In this long and uncertain period of incubation the disease bears some resemblance to syphilis, which may occasionally give rise to no definite symptoms, either local or general, till six weeks after inoculation.

Symptoms in the Dog.—The Surgeon is sometimes asked to give an opinion as to the condition of a dog that has bitten a person, and which is suspected of being mad. The following description of the symptoms of **Rabies in the Dog,** by Dr. Burdon Sanderson, will aid him in coming to a conclusion on these points.

"The premonitory indications of rabies in a dog are derived almost entirely from the observation of changes in its demeanour; consequently, although

they may be too trifling to be noticed by a casual observer, they are fortunately sufficiently striking to arrest the attention of any one who is about a dog, and is familiar with its habits and individual peculiarities.

"A dog about to become rabid loses its natural liveliness. It mopes about as if preoccupied or apprehensive, and seeks to withdraw into dark corners. From the first there is usually a foreshadowing of that most constant symptom of the disease—depraved appetite. Mad dogs devour not only filth and rubbish of every kind with avidity, but even their own excrement—often immediately after it has been passed. Indications of this tendency appear early, and are more than suspicious.

"Along with this peculiarity of behaviour it is of equal importance to notice that an infected dog, from the first, snaps at other dogs without provocation. This snappishness in most dogs is very striking. If a dog previously known to have no such habit, snaps indiscriminately at the first dog it meets in the yard or in the street, it is probably not safe.

"So far I have had in mind chiefly what is to be observed in dogs tied up or at home. A dog which is at large is also to be recognized as in a dangerous state by its demeanour. A healthy dog in its progress along a street or elsewhere shows at every step that its attention is awake to the sights and sounds which it encounters. The rabid dog, on the contrary, goes sullenly and unobservantly forwards, and is not diverted by objects obviously likely to attract it. This statement, however, is subject to the important exception already referred to, that it is excited both by the sight and sound of an animal of its own species.

"Of the symptoms which accompany the final stage of the disease, the most important and characteristic are those which relate to the organs in which it localizes itself—the mouth and throat. Attention is often drawn to the condition of the mouth in an animal supposed to be healthy, by the observation that it tries to scratch the corners of its mouth, as if attempting to get rid of the ropy mucus which is seen to be discharged from it. In dogs that are tied up, it is noticeable that the bark has entirely lost its ring, and acquires a peculiar hoarseness, which can be recognized even by the most unobservant. As the disease progresses the discharge increases, the lower jaw hangs as if paralysed, and the animal has evident difficulty in swallowing. Along with this there is often loss of power in the hind limbs. If now the dog be watched, the peculiarities of behaviour which have been already noticed are seen to present themselves in a much more marked degree than before. It is observed, first, that it is subject to paroxysms of excitement, in which it makes often-repeated efforts to bite or gnaw all objects (such as woodwork, straw, &c.) within its reach, while at the same time it continues to exhibit the tendency already mentioned to devour its own excrement; and, secondly, even during the remissions, its excitement is at once renewed by the sight or sound of another dog.

"It may be well to note that the disease occurs at all seasons, that the mad dog continues to recognize its master and to manifest pleasure when kindly spoken to, that it does not shun water, and that in many cases from first to last that wild fury which is commonly supposed to belong to the disease, is conspicuously absent."

Symptoms in Man.—The wound has generally cicatrized long before any symptoms of hydrophobia declare themselves; and no peculiar appearance is

presented by the scar. Shooting pains, twitching and itching sensations have, however, occasionally been experienced in the site of the wound before the supervention of the attack.

The symptoms are usually ushered in for two or three days (according to Perry for five or six) by some antecedent phenomena, consisting of giddiness, chills and heats, and a general feeling of discomfort. In some cases vesicles under the tongue have been observed. The more *special* symptoms never manifest themselves until the disease is fairly established ; they consist essentially in violent and repeated convulsive movements of a reflex character, induced by various external influences acting on the surface of the body or on the fauces, or by mental impressions ; and they speedily end in exhaustion and death.

The special symptoms are referable to an excessive irritability of the medulla and upper part of the cord, in consequence of which the slightest afferent impulse causes a wide-spreading and violent reflex spasm of the muscles of deglutition and respiration, and of those of the neck and sometimes of the jaw and tongue. At the same time there is considerable mental disturbance, chiefly assuming the form of excessive terror and agitation.

The **Excessive Irritability of the Medulla and upper part of the Spinal Cord** is shown first by the very slight nature of the afferent impulses which are sufficient to cause a reflex spasm. A blast of cold air, the rustling of the bed-clothes, the slightest touch of or movement on the skin, will bring on convulsions. As the disease advances, stimulation of the nerves of special sense produces the same effect ; so that a sudden flash of light before the eyes, as the reflection of the sun from a looking-glass, or a sudden noise, as the slamming of a door, will produce a spasm. Mental impressions even may cause the same result. The noise produced by liquids being poured from one vessel to another is peculiarly distressing to the patient ; and Elliotson mentions a case in which a patient with hydrophobia was thrown into violent agitation by hearing the dresser who sat up with him void urine. The sufferings and convulsions that patients experience when they attempt to drink are owing to the same cause. The normal reflex contraction of the muscles of deglutition that occurs in swallowing becomes spasmodic, and spreads widely to other muscles, ending in a general convulsion, and the recollection of these sufferings makes them afraid to repeat the attempt ; hence the fear of liquids from which the disease derives its name.

In the earlier stages of the disease the spasm affects chiefly the muscles of deglutition and respiration ; a catch in the breathing, resembling what often occurs when a person goes into a cold bath, is met with as one of the earliest symptoms, taking place in the midst of conversation, and before the patient's mind is directed to the nature of the disease. This catch is due to the spasmodic descent of the diaphragm, and gives rise to severe pain at the pit of the stomach, or to a feeling of suffocation. In consequence of this spasm of the diaphragm, the patient makes from time to time a loud hiccuping noise, which has been likened to the bark of a dog. As the disease advances the spasms extend more widely, and increase in violence. The extraordinary muscles of respiration and those of the neck and jaw are thrown into violent spasms, and the convulsions may extend even more widely. The laryngeal muscles also become affected, and spasm of the glottis is not an uncommon mode of death. Towards the end of the case the spasms may occur without

any recognizable external stimulus, but just before death they may entirely cease.

From an early stage of the case there is an abundant viscid secretion from the mouth and fauces, which the patient finds great difficulty in expectorating, often trying to pull it out with the fingers; and children may in this way scratch and tear the skin of the lips and nose.

One of the earliest symptoms, and one of the most persistent, is extreme **Mental Agitation and Terror**, a vague sense of dread and horror at the impending fate. Spectral illusions sometimes occur, the patient supposing himself to be surrounded by animals, by horrid forms, or by gaping, ghastly, and grinning countenances, by flies or wasps. The first symptom in the Duke of Richmond's case was, that he fancied some poplar-trees opposite his bedroom-window to be men looking in. These delusions may alternate with fits of delirium, terror, and frenzy. In these it is said that the patient barks like a dog, and endeavours to bite; but this is a popular error—the pretended bark is merely the catch in breathing, and the attempt to bite is nothing but movements of the tongue and mouth induced by the viscid and ropy saliva.

The temperature is not usually very high, not much over 100° F. Albumen and sugar have been found in the urine by F. A. Southam, the sugar doubtless depending on irritation of the medulla oblongata.

Duration and Termination.—The disease may prove fatal in four-and-twenty hours, or life may be prolonged for six or seven days; death generally occurring from the second to the fourth day, apparently from exhaustion.

Death may occur in various ways, from coma, from spasm of the glottis or from exhaustion.

Occasionally the symptoms subside completely before death; the increased sensibility of the surface disappearing, the mental agitation or delusion being removed, and deglutition and respiration being quietly performed. Thus, Latham relates the case of a man labouring under this disease, who sat up quietly in bed and drank a pint of porter half an hour before he died. In these cases the pulse gradually becomes slower and slower, and finally ceases to beat. This mode of death is not exhaustion, but is due to a destructive change in the cardiac centre in the medulla.

Prognosis.—I am not acquainted with any case of recovery from hydrophobia, after the disease has fairly set in. It cannot, however, be pronounced absolutely and inevitably fatal; for Radcliffe states that, of 109 authentic cases, recovery took place in 14.

Pathology.—The appearances which are found after death in undoubted cases of hydrophobia are such as to harmonize with the symptoms during life. The most definite and characteristic change is found in the lower part of the medulla, "most intense in the hypo-glossal, glosso-pharyngeal and vagal nuclei and their neighbourhood." Gowers found the changes identical and so clearly marked, that the nature of the affection could have been recognized from the post-mortem appearance alone in seven out of eight cases he examined. Nothing is visible to the naked eye, but the microscope shows ante-mortem clots in some of the minute vessels and the perivascular spaces in the affected region crowded with leucocytes. In the regions in which the disease is most advanced, the leucocytes pass beyond the lymphatic spaces and invade the tissues of the medulla, sometimes being so closely packed as to conceal the normal structures in minute spots. The only change in the nerve

elements is slight granular degeneration. The appearances are, in short, merely those of inflammation of the affected region. These appearances were very marked in a case which occurred under my care in University College Hospital in 1871. Benedikt, and others, have found identical changes in the dog. Taking the post-mortem appearances and the symptoms together, it would seem probable that the essential feature of the disease is an infective inflammation, the source of irritation coming from within the vessels. The first sign of damage to the nerve-elements is their loss of resistance, and the occurrence of violent and irregular action from slight causes. If the patient does not perish at an early stage from exhaustion, damage of the nervous tissue progresses till the latter comes to respond more feebly than natural to the different impulses it receives ; this corresponds to the period of calm before death that so frequently occurs. Finally, it becomes incapable of performing its functions, and the heart ceases to beat. Coats states that he has found in addition to the congestion of the fauces always met with, actual infiltration of the salivary glands with leucocytes. Beyond these no definite appearances are met with. What the nature of the poison is, and why it should lie so long latent and finally attack a limited portion of the central nervous system, are questions which it is at present beyond our power to answer. That the poison inoculated locally multiplies in the system and infects the whole body can scarcely be doubted, as experiments have shown that the disease can be communicated from man to dogs by the blood. Hydrophobia, therefore, most nearly resembles an acute specific disease, the period of incubation being however longer than in any other known infective process. The fact of its being communicable solely by inoculation, would not exclude it from that class of affections. Hydrophobia is not in reality more extraordinary than such a disease as mumps, in which a period of perfect health, lasting for three weeks, intervenes between infection and the appearance of a local acute inflammation attacking the parotid gland. The nature of the poison has not yet been ascertained. The efforts to discover a specific microscopic organism in the saliva and blood of rabid animals cannot as yet be said to have been successful.

Treatment.—This must be principally *preventive* and *palliative*. We cannot speak of *curative* treatment of hydrophobia ; for, after the disease has once set in, the utmost that can be done will not accomplish more than to lessen the patient's sufferings, and stay for a few hours the almost inevitably fatal termination.

When a person is bitten by a rabid dog, or even by one that is reasonably supposed to be so, the Surgeon should always adopt energetic means to save the patient from the invasion of so fatal a disease. In having recourse to preventive treatment, it should be borne in mind that the larger proportion of persons actually bitten by rabid animals do not fall victims to hydrophobia ; the probability of the occurrence of the disease depending partly upon the animal that bites, and partly upon whether the bite is inflicted on the naked or on the clothed part of the body, and possibly also on individual susceptibility to the disease, as has already been stated. It is in consequence of this small proportion of persons taking the disease out of the total number bitten, that so many popular remedies and superstitions have obtained an unmerited reputation for preventing the disease.

As soon as possible after the bite has been inflicted, a string or bandage of some kind should if possible be applied on the proximal side of the wound, so

as to arrest the circulation. Suction is commonly recommended, and would be almost instinctively practised; but it is not altogether devoid of danger, as there is reason to believe that inoculation may take place through the mucous membrane of the mouth, and would certainly occur if there were any crack or abrasion. The only preventive means that can be trusted by a Surgeon, are *excision* and *caustic.*

Excision of the part bitten should be carefully and freely performed, no half measures being had recourse to. Hence it is better to remove too much of a comparatively unimportant tissue or part, than to allow the sufferer to run any risk of falling a victim to the fatal disease. In order to excise every part that has been touched by the tooth, the Surgeon, after washing the wound and contiguous surface with strong carbolic-acid-lotion, should make a circle with ink, or tincture of iodine, completely round the injured part. He must then pass a probe to the bottom of the wound, and excise the whole by scooping out a conical piece of the tissues, taking care to go beyond the furthest limit to which the probe is passed. If there be any doubt of the removal of the whole of the injured parts, potassa fusa should be applied. If the lip be bitten through, a portion should be cut out, and the wound brought together, as in hare-lip operations; if a finger be injured, it should be amputated. When the wound is so situated that excision cannot readily be performed, potassa fusa, or strong nitric acid, or nitrate of silver, as recommended by Youatt, should be freely applied to every corner of it. Of these various caustics nitric acid is the best, as it penetrates most easily into all the crannies of the wound. If the wound have already cicatrized, the bitten part should be excised at any time after the injury, provided the dog is known to have been mad, or to have become so afterwards; for it is not impossible that, in the cases in which the disease has occurred at a remote period, it has been dependent upon, or connected with, some peculiar action set up in the wound, which might possibly be averted by the removal of the cicatrix.

I forbear to speak of any other means of constitutional preventive treatment, as I consider them utterly undeserving of confidence.

After the disease has once set in, nothing can be done but to *palliate symptoms* and to prolong life. Every possible remedy that the ingenuity of man could devise, from warm water to viper- and ticuna-poison, has been tried, and been found utterly useless.

But, although no treatment hitherto tried has been successful in curing, much may be done to mitigate the sufferings induced by this horrible disease. With this view, all source of external irritation, whether physical or mental, should be removed. The patient should be placed in a darkened and noiseless room, and not subjected to the intrusive curiosity of strangers; and the bed should be surrounded by gauze curtains or screens, so as to prevent the disturbing influence even of a draught of cold air blowing on the surface. Chloroform may be administered by inhalation, or chloral injected subcutaneously in 10 to 15 grains doses every second or third hour, in order to calm the violence of the spasms and to procure sleep, but care must be taken not to push it too far lest coma result.

The hot air or vapour bath often affords great temporary relief, and diminishes in a marked manner the violence of the spasms.

The subcutaneous injection of curare has been strongly recommended by some, and doubtful cases of cure by its means reported. The dose is from the

$\frac{1}{6}$th to $\frac{1}{4}$th of a grain every third hour. This powerful drug undoubtedly paralyzes the voluntary muscles, and may thus arrest the spasms. But its use is attended by a special danger—viz., that of paralyzing the muscles of respiration, and thus asphyxiating the patient; and, indeed, by it, and by similar means, we but treat a symptom, and do not attack the real disease. Still, the mitigation of so painful a symptom as repeated spasms is a great comfort to the patient, and smooths the way to the grave—hence the use of it, and of other sedatives is justifiable. Tracheotomy has been recommended by some in order to avert death by spasm of the glottis. But what possible good can result from preventing death by this cause when it is impending from another? What advantage can there be in submitting a patient to tracheotomy when he is about to die from coma or exhaustion? Lastly, the Surgeon must bear in mind that he has to treat an exhausting disease, and that he must consequently support the patient by wine, beef-tea, and such nourishment as can be taken.

MALIGNANT PUSTULE.

Malignant pustule or charbon is the name commonly given to the affection produced by the inoculation, on the cutaneous surface in man, of the virus of the disease of cattle known as splenic fever, anthrax, or the quarter-evil. Splenic fever is fortunately rare amongst animals in this country, while in France and some parts of Germany it occurs with considerable frequency amongst horned cattle, horses, and sheep. Malignant pustule is consequently also rare, being met with chiefly amongst workers in foreign hides or wools; on the Continent it is common also amongst butchers. The virus has now been clearly proved to be a large, easily recognizable microscopic organism, the bacillus anthracis. It may find entrance into the body in the form of dust by the lungs or intestines, and then gives rise to a general disease running a rapid and fatal course without the formation of an external centre of inflammation. This affection which is known as "woolsorter's disease" has lately been brought prominently into notice by the occurrence of several fatal cases at Bradford amongst workmen engaged in sorting Persian and Bokharan wools. Malignant pustule assumes an importance quite out of proportion to the frequency of its occurrence; first, because of the necessity of recognizing it early for its successful treatment; and secondly, because it forms a type of a true infective process, both local and general, and its exact pathology is better understood than that of almost any other similar disease.

Symptoms.—The first symptom of malignant pustule is the formation of a small angry red pimple on some exposed part of the body—either the face, hands, or arms. The patient may be conscious of having scratched or pricked himself at the point at which the pimple appears, or he may rightly or wrongly attribute it to the bite or sting of an insect. The pimple is accompanied by intense itching, and after some hours a vesicle forms on its summit, which is burst by the patient's scratching it. There now forms a distinct indurated patch, which rapidly extends; at first it is grey in colour, but by the end of the second day the central part is black. The skin in the neighbourhood becomes red and swollen, and round the edge of the black patch a ring of vesicles is formed. The individual vesicles are about the size of mustard seeds. There now follows considerable swelling of the surrounding parts with enlargement of the neighbouring lymphatic glands, and if the pustule is seated

on the arm, red lines may run up towards the axilla. The rate of progress varies considerably, but by the fifth or sixth day the black eschar may reach the size of a florin, and the surrounding swelling may affect the whole side of the face or the greater part of the arm. Beyond the itching there is but little pain. The constitutional symptoms are not severe at first, but by the fourth or fifth day the temperature rises to 101° or 102°, the pulse becomes quick and irregular, the tongue dry, and the patient suffers from headache, and a feeling of general severe illness. There may be dyspnœa or fainting, diarrhœa and occasionally delirium. If no treatment be adopted, the case most frequently terminates fatally under a week from its commencement. The whole process may, however, remain local and cease by itself, the redness subsiding, the slough separating, and the resulting granulating sore healing with considerable disfigurement. This favourable termination is, however, of great rarity.

In some exceptional cases, the result of the inoculation may be a widely diffused œdema without the formation of a distinct localized inflammation. This form is rapidly fatal. If the patient survive beyond three or four days eschars and pustules may form in the swollen part. This form has been described by the French writers under the name of "*malignant œdema.*"

The internal form—"*woolsorters' disease,*" or, as it has been called, *anthracæmia*—belongs rather to the Physician than to the Surgeon. The disease begins with a great sense of illness—sometimes with a rigor—vomiting, and headache, followed by high fever, marked dyspnœa, and cold extremities; usually fatal collapse rapidly ensues. The disease may assume a pulmonary form, in which the symptoms resemble acute pneumonia or bronchitis; or an intestinal form, in which vomiting and purging are marked features. The whole illness may last under two days, or may be prolonged to four or five. Woolsorters' disease is extremely fatal.

The **diagnosis** of malignant pustule is not difficult when the characteristic features are well developed. The black eschar, surrounded by vesicles, around which again is a bright red zone, and the wide-spreading œdema are characteristic. If there is any doubt, microscopic examination of the blood or inflammatory exudation will clear up the doubt.

Pathology.—After death from malignant pustule, the body presents the appearances usually met with in cases of malignant blood-poisoning. Rigor-mortis is of short duration and feebly marked, there being frequently early decomposition and marked post-mortem staining of the tissues. The blood is dark in colour, and imperfectly coagulated, and minute petechiæ and extravasations of blood are found beneath the serous and mucous membranes throughout the body. There is swelling of most of the abdominal viscera, but the spleen, especially in the lower animals, shows the greatest change: it is swollen, black in colour, soft, and sometimes almost diffluent; the mucous membrane of the stomach and intestines is frequently redder than natural, and may be marked by hæmorrhagic patches. The lungs are usually gorged with blood, especially at their bases.

Locally it is found that the eschar is hard and dry, and penetrates deeply into the subcutaneous tissue, but not beyond. The neighbouring lymphatic glands are enlarged and redder than natural.

Microscopic examination of the local affection of the blood and of the viscera shows everywhere the presence of a distinct microscopic organism of

considerable size—the bacillus anthracis (Fig. 122). This organism was discovered by Pollender as long ago as 1849, but its complete life-history and its definite relation to splenic fever have been but recently worked out by Chauveau, Davaine, and Pasteur in France, Koch in Germany, Ewart and Greenfield in this country, and a multitude of other observers. The bacillus anthracis is a rod-shaped organism, varying in length from $\frac{1}{2500}$ to $\frac{1}{1250}$ of an inch, and of an average breadth of about $\frac{1}{18000}$. Thus in human blood their length may reach between two and three times the diameter of a red corpuscle, and their width to about one-quarter of its thickness. By cultivating it in suitable fluids out of the body its mode of growth can be observed. It multiplies when growing actively by increasing in length till it reaches a certain size, and then dividing by fission at or near its middle. When growing in this way the filament remains homogeneous in structure throughout; it is easily destroyed by exposure to a moderate degree of heat, by carbolic acid, and all other chemical antiseptics. Under conditions less favourable for this active mode of growth minute highly refracting dots, which have been proved to be spores, are seen to appear in the protoplasm of the bacillus. After this the organism may break up, leaving only the spores recognizable, surrounded by a little jelly-like material; or the spores may be quite free, or still situated in very short segments of the original rods. It has been proved by experiment that under proper conditions these spores grow into the fully-developed bacilli, that they are really genuine germs of the fungus. From their extremely small size it is evident that if dried they could without difficulty be transported from one place to another as dust in the air, and it is, in fact, these dried spores that serve as the poison both in malignant pustule and woolsorters' disease as seen in this country. The power of resistance of the spores to injurious influences is so great as to render the task of disinfection after splenic fever undoubtedly difficult. The experiments of Robert Koch have shown that blood containing spores of the bacillus may be dried, and allowed to even putrefy in drying, and kept afterwards for years without losing its virulence. The spores may be exposed to a moist heat of 212° F. for a very short time, or to a dry heat for a longer period, without injury. Alcohol, glycerine, watery solutions of carbolic acid (1 to 20), salicylic acid, thymol, and weak solutions of permanganate of potash, are impotent to arrest their development. On the other hand, freshly prepared chlorine-water, bromine (2 per cent. solution), iodine-water, bichloride of mercury (1 per cent. solution in water), or permanganate of potash (5 per cent. in water) destroy their vitality without difficulty. Fortunately, so far as is at present known, the ordinary bacteria of putrefaction, and all micrococci, multiply solely by fission, without the formation of spores, and consequently are destroyed by heat and chemical antiseptics without difficulty.

Fig. 122.—Bacillus Anthracis in connective tissue. *v*, Small vein, containing bacilli; *bc*, Capillaries, choked with bacilli; *x*, Nuclei of cells, forming capillary wall; *n'*, Nuclei of connective-tissue-corpuscles; *l*, Small amount of lymphoid tissue.

That this organism is the actual cause of the disease is proved by the fact

that when the bacillus is in the spore-bearing stage it may be washed with distilled water, alcohol, and ether, and then dried, and after all this, if inoculated, it is capable of producing splenic fever in the animal experimented on. After inoculation it produces its local effects probably by setting up chemical changes of a fermentative character in the fluids of the part, giving rise to the production of intensely irritating products, which, by a process analogous to cauterization, cause inflammation, and, soaking into the surrounding lymph-spaces, give rise to the spreading œdema and inflammation beyond the area in which the organisms are actually growing. When the bacilli get into the blood and grow widely throughout the body, they are supposed to act partly by causing mechanical obstruction of the capillaries, and partly by robbing the blood of its oxygen; for, like all fungi, they absorb oxygen and excrete carbonic acid during their growth. This would account for the dyspnœa and cyanosis usually met with before death from malignant pustule.

One more point may be briefly noticed. Pasteur discovered the interesting fact that, by cultivating the organism in a medium not well suited to its growth, the intensity of its virulent action becomes attenuated, until after a few generations have been thus grown a degree of attenuation is reached in which the effect produced by inoculation, although severe, is certain not to be fatal; and that after the animal has suffered from the modified form of the disease it may be inoculated with the unattenuated virus without effect. The analogy between this process and vaccination has given a peculiar interest to Pasteur's observations, and numerous observers have repeated his experiments with the result of generally confirming his observations. The subject is, however, still incompletely worked out.

In malignant pustule and splenic fever we have, therefore, a disease which is analogous to many conditions met with in unhealthy wounds. There is a peculiar local inflammation, the products of which excite a similar process in the parts with which they come in contact; the poison multiplies in the living tissues and is communicable from one individual to another by inoculation, or, under certain circumstances, by the air; finally the whole system becomes affected, and grave blood-changes occur, which are incompatible with life. The same conditions are met with in many forms of septic infection (septicæmia), in some forms of pyæmia, in dissection-wounds, in spreading gangrene, in diphtheria, &c.; and in all these affections microscopic organisms of various kinds have been seen, both in the discharges and in the blood. Reasoning from analogy therefore, one would be inclined to assume that, as in splenic fever, so in these diseases, the organism is the immediate cause of the morbid process. In science, however, analogy cannot be accepted as proof; the most it may be allowed to do is to suggest a hypothesis. The hypothesis thus suggested has served for some years past as the guide in all experimental inquiries in this class of diseases, and to a great extent also in their treatment, and it may reasonably be hoped that before long definite proof of its truth will be obtained.

The **Treatment** of malignant pustule must be energetic and active: no half measures are likely to be successful. The whole indurated area of the skin should be removed by the knife, and to the raw surface thus left some strong antiseptic should be applied; perhaps the best would be a strong solution of iodine, which has been shown by Koch to be capable of destroying even the spores of the bacillus.

In London, malignant pustule has been most frequently seen at Guy's Hospital, as the chief part of the hide trade is carried on in the neighbourhood of that Institution; and during the last ten years seventeen cases have come under the care of the Surgeons. The treatment by excision has been employed in fifteen cases, and of these all but two recovered. The favourite application after excision has been chloride of zinc, either in a strong solution or as a paste. Davies-Colley, who reports these cases in the Transactions of the Medico-Chirurgical Society for 1882, states that "it is very important to remember that, even after the swelling has extended to a considerable distance, and the adjacent glands have been affected, and after well-marked symptoms of blood-poisoning have developed themselves, the patient may be restored to health by the removal of the indurated area of skin which was primarily attacked."

GLANDERS.

Glanders is a virulent disease, communicable by contagion to man from the horse, ass, or mule. In spite of the intense contagiousness of the disease and the frequency with which it occurs among animals of the equine race, it is rarely met with in man.

The poison of glanders gives rise to two forms of disease in the horse, one known as *glanders* proper and the other as *farcy*.

Glanders in the Horse almost invariably runs a chronic course. The first symptom is a thin watery discharge from the nose, which, as the disease progresses, becomes viscid and tenacious; lastly it becomes purulent, offensive, and mixed with blood. The inflammation extends through the whole nasal cavity and frontal sinuses, and is accompanied by ulceration. There is also marked swelling of the lymphatic glands under the jaw. The disease may exist for some time without seriously impairing the health of the animal, but gradually loss of appetite and strength, emaciation, and cough set in, and death takes place from exhaustion. Before death the disease always becomes complicated by the second form or farcy.

Farcy is characterized by swelling of the lymphatic glands in various parts of the body, especially on the inside of the thighs, and under the fore leg. The lymphatic vessels leading to and from the glands become inflamed, forming hard, tender cords with swellings opposite the valves. These form the "corded veins" and "farcy-buds" of the farriers. The swellings opposite the valves enlarge and become adherent to the skin, and finally ulcerate, forming foul sores. The disease may at any time become complicated with acute glanders. Acute glanders is merely a great exaggeration of all the symptoms with high fever, hurried respiration, and cough.

The post-mortem appearances of glanders in the horse are a dark redness and swelling of the pituitary membrane, with numerous small white elevations and patches, softening in the centre so as to form ulcers. A similar condition extends to the mucous membrane of the bronchi. In the lungs are numerous consolidated patches, varying in size from a millet-seed upwards, opaque yellow in colour, and softening in the centre, sometimes having the appearance of minute abscesses. With these may be patches of pneumonia. Gamgee describes as occasionally present in the lungs large masses of a bluish white colour and lardaceous appearance, sometimes as big as a hen's egg. Sub-serous petechiæ are common.

Glanders and Farcy in Man usually occur together and run an acute course, although occasionally they may become chronic. The disease is always communicated by inoculation, usually into a scratch or other wound; but cases have been recorded in which it seemed to have been communicated through unbroken mucous membrane. The inoculation is followed by a period of incubation, which is said to last a variable time from two days to two weeks. The invasion is marked by fever and a great sense of illness. There may be rigors, vomiting, and diarrhœa. In some cases there have been such severe pains in the limbs that the disease has been mistaken for rheumatism. The seat of inoculation becomes inflamed, and the nearest lymphatic glands become enlarged and tender. Inflamed lymphatic vessels, with hard knots opposite the valves, may also be present. At a period after invasion varying from two days to a week or more, a characteristic *eruption* makes its appearance. This consists at first of red spots like flea-bites, which soon assume the form of elevated yellowish tubercles situated in the structure of the true skin or immediately beneath it. From their shot-like feel they may at first resemble the early stage of small-pox pustules, but they are not umbilicated and are more deeply situated, as shown by Boyd. They soon soften, forming minute abscesses in the cutis vera, the contents of which are at first hæmorrhagic. They then burst, leaving small yellowish ulcers discharging a thin purulent fluid. With these may be also a vesicular eruption. There soon sets in an offensive discharge from the nose, at first watery, but afterwards puriform, and the lymphatic glands under the jaw enlarge. Finally, subcutaneous abscesses form in various parts, which may be accompanied by hæmorrhages into the muscles and intermuscular tissue; pneumonia or pleurisy may occur before death. Abscesses may be found in internal organs, as the liver or lungs. The final stages resemble pyæmia in many respects. Throughout the case the constitutional symptoms are of the gravest kind. There are great depression, high fever, delirium, and rapid emaciation. In some exceptional cases the disease may run a very chronic course.

Diagnosis.—The disease may resemble rheumatism before the eruption appears, but the appearance of this soon clears up the case. The eruption, as before stated, somewhat resembles that of small-pox, but the general symptoms of this disease are wanting. The history of the association of the patient with glandered horses is an important element in the diagnosis.

Pathology.—The post-mortem appearances are much the same as those observed in the horse. There are the usual signs of grave blood-poisoning—early decomposition, excessive blood-staining of the vessels and tissues, and subserous petechiæ. Scattered points of suppuration are found throughout the body, and sometimes extensive hæmorrhage into the muscles. The lungs are usually more or less consolidated from pneumonia, and contain yellow nodules, softening in the centre, like the so-called pyæmic abscesses.

The nature of the virus has been the subject of much discussion. At the end of 1882 Schültz and Löffler, two of the assistants in Koch's laboratory in Berlin, discovered the presence of a bacillus of a definite form in all the parts affected with the specific processes of glanders. This bacillus was cultivated for four generations out of the body in the serum of horse's blood and finally inoculated on two healthy horses. Both animals speedily died with all the symptoms of glanders. It seems, therefore, that this bacillus is directly con-

nected with the disease either as the actual virus itself or as an essential factor in its production.

Duration.—The disease proves fatal usually in a week or fortnight, but may extend to a month. It occasionally assumes a chronic form in the human subject and lasts for several months.

Prognosis.—If the disease assumes the acute form death is almost certain to follow. When it becomes more chronic, according to Durham, about half recover.

Treatment.—Beyond the general treatment of supporting the patient, opening the abscesses, and freely using antiseptics both for the nose and the local sores elsewhere little can be done. Those who have care of the case must protect their hands by india-rubber gloves, if possible, while dressing the sores; and all dressings or rags which have become soiled with the discharges must be immediately burned.

WOUNDS WITH INOCULATION OF DECOMPOSING ANIMAL MATTER,* AND THE PRODUCT OF UNHEALTHY INFLAMMATIONS.

The majority of wounds of this character are not dangerous. Every student of anatomy frequently punctures and cuts himself in dissecting, but we rarely see any ill effects from these injuries. In some cases, however, the most serious results, terminating in permanently impaired health, or even in death, ensue. The result depends quite as much on the state of health of the person injured, as on the condition of the body from which the poison is received. If the health be broken by any cause, whether excess of study or dissipation, or over-fatigue in professional work, very serious effects may follow, which would not occur if the patient had the resisting power of a sound and strong constitution. Many persons are peculiarly liable to be injuriously affected by exposure to septic influences. They suffer in various ways, as from depression of the nervous system, sore throat, or diarrhœa—from working in dissecting or post-mortem rooms. The same happens from exposure to the contaminated atmosphere of a crowded hospital-ward, and more especially to the exhalations arising from patients affected with phlegmonous erysipelas, pyæmia, gangrene, or other septic diseases. The susceptibility is greatest in those least frequently exposed to such infections. After a time a student becomes acclimatized, and those who habitually work in such atmospheres seem to feel the evil influence least. If, for a time, the habit is broken, they suffer on resuming their work as much as those exposed for the first time to these septic contaminations. A person so suffering in health is rendered peculiarly liable to local or general infection on the receipt of a dissection-wound.

Causes.—The deleterious influence exercised by the dead body, human or brute, may be attributed to three different causes: 1, the ordinary Irritation of the Wound; 2, Inoculation of Putrid Matter; or, 3, Introduction of a Specific Septic Virus into the system. I think it probable that each of these causes may exercise a distinct influence; but the worst effects of dissection-wounds are dependent on the inoculation of a peculiar and specific virus.

1. That ill effects sometimes result from the simple **Irritation of the Puncture**, is evident from the fact that mere scratches or punctures with splinters of wood, or other substances free from an actual poison, give rise to

* See also Chapter XXXI—Septicæmia.

considerable local disturbance in certain states of the constitution; so, also, those operation- and dissection-wounds which are ragged and torn, such as are made by spicula of bone or the teeth of a saw, are peculiarly troublesome.

2. **Putrid Animal Matter** is always irritating, but, as has before been pointed out, putrefaction cannot attack living tissues, and the effect produced is consequently limited to the local irritation caused by the chemical products of the process. A small puncture, which if made with a clean knife, would heal by the first intention, may, if exposed to the irritation of putrid animal matter, inflame and suppurate, forming a small ulcer; but, unless the general health be seriously impaired, no further trouble is likely to occur. The worst effects of dissection-wounds result from those received before putrefaction has set in, and the most dangerous wounds more commonly occur in *post mortem* inspections made a few hours after death. Dissecting-room investigations on parts in an advanced stage of decomposition are practically free from danger.

3. The worst forms of *post mortem* wounds arise from the inoculation of the **Specific Virus** of some infective inflammation, such as erysipelas, pyæmia, and septicæmia, and more especially from punctures received in examining the bodies of those who have died of diffuse peritonitis following parturition or the operation for hernia. The virus is contained in the exudation fluids from the unhealthy inflammation, and its nature has already been alluded to when discussing the causes of inflammation. The fluids capable of causing these serious poisoned wounds invariably contain microscopic organisms—usually micrococci, occasionally bacilli; and the great majority of pathologists believe them to be either the actual virus, or to be inseparably connected with its production. The diminution of the intensity of the poison when putrefaction sets in is supposed to be due to altered conditions after death, which are more favourable to the development of the ordinary bacteria of putrefaction and less favourable to the growth of the specific organisms which consequently perish. However, it is to be explained, the fact is undoubted, that the greatest danger exists before putrefaction sets in. A few hours after death, whilst apparently still quite fresh, the body is in the highest degree infective and dangerous; advanced putrefaction lessens the danger. Of all *post-mortem* poisons, that which is generated in septic peritonitis, whether following parturition or operations involving the abdominal cavity, is by far the most noxious. The acrid fluid which accumulates in the peritoneum when that structure is attacked by diffuse inflammation of the kinds just mentioned, appears to exercise a specific injurious influence. I believe it to be impossible to immerse the hand in it with impunity if there should happen to be a scratch, puncture, or abraded surface of any kind on it. Inoculation would, under such circumstances, inevitably ensue, followed by diffuse inflammation to a greater or less extent. It is, however, by no means necessary for *post mortem* infection, that there be an abraded or broken surface through which the inoculated matter may be introduced into the system. Imbibition may take place through the unbroken cuticle; and not unfrequently it is through the medium of the hair-follicles that the septic poison enters. In the graphic account given by Sir James Paget of his own case, the poison is stated to have been absorbed through the unbroken cuticle of the hand immersed in pyæmic effusion into the pleura. I have known poisoning through the hair-follicles of the back of the hand to happen to another very distinguished member of

our profession. In other cases, again, infection appears to have taken place by absorption under the semilunar fold of skin at the base of the nail. That the poisonous influence from the bodies of persons who have died of septic diseases is transmissible to others by contact or infection, cannot be denied; and accoucheurs and operating Surgeons should abstain as carefully as possible from performing *post mortem* examinations on patients dying from such diseases, lest the poison be carried to and excite similar morbid processes in their own patients. Much of the septic disease that used formerly to prevail in hospitals was engendered in this way, and infective disease has often thus been carried out of hospitals and communicated to private patients by Surgeons neglecting hygienic precautions.

Symptoms.—From what has been stated above, it would appear that there are two distinct kinds of mischief resulting from dissection-wounds. First, the purely local form, proceeding from the irritation of putrid matter acting on the unbroken skin, or on a scratch or wound, and, secondly, the true infective form, spreading widely from the point of inoculation.

Of the purely local affections, the most common is the small pustule so often met with in the dissecting room. About twelve to twenty-four hours after inoculation the punctured part becomes painful, hot, and throbbing; at the end of about forty-eight hours a small drop of pus is seen raising the cuticle. If this be punctured, a small superficial sore is seen beneath, and the pain is at once relieved. If the sore be now properly dressed it heals without trouble, but if not, a small scab forms, the pus accumulates beneath it, the pain and throbbing return, and are again relieved by removing the scab. This may be repeated several times. There is neither glandular swelling nor constitutional disturbance.

Suppuration in the hair-follicles and the formation of boils is an occasional result of the action of putrid fluids on the unbroken skin of the hands.

A somewhat rare affection resulting from the frequent and prolonged contact with putrid matter is the so-called *dissecting-porter's wart* or *anatomical tubercle*. It is always seated on the knuckles or back of the hand. It consists of a warty thickening of the skin without ulceration. The surface may be moist, and the discharge if allowed to dry may form crusts; in other cases it may be scaly on the surface. The enlarged papillæ are closely set, and the diseased condition tends slowly to spread. In the case of one of the dissecting porters at University College who suffered from this affection, the patch measured about one inch and a half in diameter. It was cauterized without much effect, and was finally cured after many months' treatment by keeping it constantly moist, so as to prevent the formation of crusts on the surface, and by the prolonged application of equal parts of extract of belladonna and glycerine.

The infective processes that arise from dissection-wounds assume two forms. In the *milder form* the punctured part becomes painful, hot, and throbbing, in from twelve to twenty-four hours after the injury; the finger swells and inflames, the lymphatics of the arm are perhaps affected, and the glands in the axilla become enlarged. There is general febrile disturbance, ushered in by rigors, a feeling of depression, and often intense headache; suppuration takes place about the puncture, and also, perhaps, in the inflamed glands, the case presenting the ordinary characters of whitlow with inflammation of the lymphatic vessels and glands.

In the *more severe form* of dissection-wound, the patient is seized, about twelve or eighteen hours after the puncture, with rigors, anxiety of countenance, and depression of the nervous system; with a quick pulse, and high fever. On examining the finger, a pustule, or vesicle, with an inflamed areola, may be observed in the situation of the puncture; from this a few red lines may be seen extending up towards the arm-pit, where there may be swelling and tension. In the worst cases, however, the signs at the seat of inoculation may be either wanting or scarcely recognizable. Suppuration, with much pain, takes place in the pectoral and axillary regions; it is usually diffuse, the pus being mixed with shreds and sloughs. The general symptoms gradually assume an asthenic type; the tongue becomes brown, sordes accumulate about the lips and gums, low delirium sets in with a rapid feeble pulse, and death occurs in from ten days to three weeks. When incisions are made into the brawny tissue, it is found infiltrated with thin pus, and in a sloughy state. If the patient live, large circumscribed abscesses form under the pectoral muscles, in the axilla, and above the clavicle, accompanied by much exhaustion and depression of the system. The convalescence is tedious and prolonged, and the constitution is often shattered for life.

In other cases a diffuse inflammation identical in all its characters with the so-called phlegmonous or cellular erysipelas spreads directly from the seat of inoculation. That this form of dissection-wound is of a truly specific character, is evident from the fact that patients labouring under it may communicate fatal erysipelas to their nurses and attendants; as happened in the case of the late J. P. Potter, of University College Hospital, whose early death was much to be lamented. It is this kind of dissection-wound that is especially apt to occur after punctures, received from patients who have died of diffuse inflammation of the serous membranes.

Sometimes the intensity of the spreading inflammation is such that it terminates rapidly in gangrene of the affected part, and the disease then resembles in most of its features genuine spreading or traumatic gangrene. A case of this kind occurred in a nurse under the care of Christopher Heath in University College Hospital in 1880. It resulted from the prick of a pin received in laying out the body of a lady who had died of puerperal fever. The patient's life was saved only by amputation at the shoulder-joint on the sixth day after the accident. In this case, as is usual in this form of disease, there was no enlargement of the lymphatic glands in the axilla.

The symptoms produced by contact, independently of any wound, with the bodies of persons who have died of erysipelatous diseases or pyæmia, sometimes vary, though still referable to the introduction of a poison. Thus I have known a body to infect seriously in different ways six students who were working at it. Two had suppuration of the areolar tissue, under the pectorals and in the axilla; one was seized with a kind of maniacal delirium; a fourth had typhoid fever; and the remaining two were seriously, though not dangerously, indisposed.

Treatment.—On the receipt of a puncture in dissection, or in making a *post mortem* examination, the best mode to prevent injurious consequences is to tie a string tightly round the finger above the injury, thus causing the blood to flow, and perhaps to carry out the virus with it. The part should then be well washed in a stream of cold water at a tap, or better still in a solution of carbolic acid (1 to 20 of water), and sucked for some minutes; in

this way any poisonous matter that has been introduced may usually be got rid of. It is better not to apply caustics ; they only irritate and inflame the finger, and can do but little good. Dissectors should bear in mind that the state of the constitution exercises great influence upon the effects of the puncture ; and, that, in proportion as the health is sound and the body not exhausted by over-fatigue, there is less likelihood of any injurious consequences ensuing.

In the slighter forms of dissection-wound, attended by a moderate amount of inflammation, the whole finger should be thickly incased with extract of belladonna diluted with an equal quantity of glycerine ; this should be covered with cotton-wool, the hand elevated and kept at absolute rest in a sling or in a splint. If the absorbents become inflamed, the belladonna and glycerine should be thickly painted along their course, and the arm enveloped in cotton-wool.

The general treatment of clearing out the bowels with a free calomel purge, followed by moderate stimulation, must be adopted in the early stage ; but tonics and strong support will soon be required, and, if there be much constitutional irritation, opiates may advantageously be administered.

The treatment of the more severe forms of dissection-injury consists principally in the application of belladonna- and hot fomentations in the early stages, followed by early and very free incisions into the finger, axilla or pectoral region, or wherever else the part may become tense and brawny. These should be made, if there is much tension, even though matter have not already formed, with a view of preventing suppuration. Should abscesses form, they must be opened early. All incisions should be made with antiseptic precautions, and treated afterwards by some of the modes of antiseptic dressing already described. Even when sloughs have formed, they are not putrid, and the patient's danger will be greatly increased should they be allowed to become so. In the constitutional treatment, our great reliance, after clearing out the intestinal canal by a free purge, is on the administration of bark, ammonia, wine, and brandy, with such fluid nourishment as the patient can take ; the case being treated as one of the worst forms of asthenic inflammation. If the patient survive, he must be sent as soon as possible into the country, and must devote some months, perhaps, to the re-establishment of his health. The punctured part often continues irritable for a great length of time, even for many years, remaining red, inflamed, and desquamating, pustules sometimes appearing on it. This condition is best remedied by the occasional application of nitrate of silver.

In conclusion, I cannot too strongly urge upon the dissecting student that unless he take scrupulous precautions as to cleanliness and disinfection, he may readily contaminate with septic poison any patient whose wound he dresses. No dissecting student or operating surgeon, who has examined a dead body, ought to approach a patient who has a wound without having previously changed his clothes, and, after washing, soaked his hands in carbolized water, or otherwise disinfected himself.

CHAPTER XII.

EFFECTS OF HEAT AND COLD.

BURNS AND SCALDS.

A **Burn** is the result of the application of so great a degree of heat to the body as to produce either inflammation of the part to which it is applied, or charring and complete disorganization of its tissues. A **Scald** is occasioned by the application of some hot fluid to the body, giving rise to the same destructive effects as are met with in burns, though differing from them in the appearances produced.

Local Effects.—Burns and scalds vary greatly in the degree of destruction of tissue to which they give rise; this variation depending partly upon the intensity of the heat, and partly upon the duration of its application. The sudden and brief application of flame to the surface produces but very slight disorganization of the cuticle, with some hyperæmia of the skin. If the part be exposed for a longer time to the action of the flame, as when a woman's clothes take fire, the cutis itself may be disorganized; and if the heat be still more intense, as when molten metal falls upon the body, the soft parts may be deeply charred, or the whole thickness of a limb destroyed. So, also, the effects of scalds vary greatly, not only according to the temperature of the liquid, but according to its character; the more oleaginous and thick the fluid, the more severe, usually, will the scald be.

These various results of the application of heat to the surface have been arranged by Dupuytren into six different degrees of burn. This classification is not merely a fanciful, nor a purely pathological, arrangement of the effects produced by the application of heat; but it is of great practical importance, as the degree and character of the resulting cicatrix are dependent on the depth to which the burn penetrates into the tissues. Hence the future condition can be determined by ascertaining, in the first instance, the degree to which the burn belongs.

In the *first degree*, the application of fire has been momentary. It has been followed by redness and pain. There is dilatation of the vessels, simple hyperæmia, but no destruction of tissue; and consequently there is no resulting cicatrix. The constant repetition of a burn of this degree may, however, cause a disturbance of healthy nutrition; thus in old people who sit constantly before the fire or over charcoal foot-warmers, changes are gradually induced in the integuments of the lower extremities.

In the *second degree* the damage done by the heat is sufficient to cause dilatation of the vessels, retarded flow, and exudation. The corneous layer of the cuticle is loosened and raised from the Malpighian layer by the exudation from the vessels of the inflamed cutis, and thus vesicles or blisters are formed. When these burst, the surface left beneath is still completely covered with epithelium. There is no loss of substance beyond that of the corneous layer

of the cuticle. The raw surface left may discharge a little puriform fluid, the cells which it contains being partly young epithelium from the Malpighian layer and partly leucocytes which have wandered to the surface. Although no cicatrix results in these cases, yet discoloration of the integument is often left. If the cuticle be not removed, the inflammation speedily subsides and is followed by some desquamation.

In the *third degree* the whole of the cuticle is destroyed, with a portion of the true skin; but the *cutis vera* is not entirely destroyed. This is a most important point, as it influences materially the character of the resulting cicatrix.

The thin layer of the true skin remaining contains sweat-glands, hair-follicles and elastic tissue—structures which are not reproduced if once destroyed. Moreover, round each hair, in the ducts of the sweat glands and in the hollows between the papillæ, epithelium is left undestroyed, from which new cells can start growing. The tips of the papillæ have their epithelium completely destroyed, and consequently become covered with granulation-tissue, so that the whole surface becomes vivid red and suppurates freely. It covers, however, with epithelium with marvellous rapidity, owing to the innumerable points from which the new cells start growing. It scarcely contracts in healing, and the scar that results is elastic and contains all the elements of normal skin. Owing to the exposure of the nerve-endings in the papillæ this form of burn is intensely painful.

In the *fourth degree* there is destruction of the skin through its whole thickness, so that the subcutaneous tissue is reached. The eschar separates by ulceration from the surrounding parts, and a large granulating sore is left which can become covered by epithelium from its edges only. Consequently the healing is slow and attended by long continued suppuration and great contraction. The resulting cicatrix is, therefore, much smaller than the original raw surface, and is devoid of glands, hair, and elastic tissue; at first it is thin, red or purplish, glazed, often in the form of bands or bridles, and is liable to occasion great deformity by the cohesion of parts, as of the fingers, or by contraction, as at the elbow, and the side of the neck and face, or by the closure of apertures, as of the nostrils.

In the *fifth and sixth degrees* the destructive influence of the burn penetrates to a greater or less depth into the muscles, bones, or joints. In the fifth degree, the more superficial muscular structures are implicated: in the sixth degree the whole thickness of the limb is destroyed and charred.

This is very briefly the celebrated classification introduced by Dupuytren, and adopted by most writers on the subject as a practical exposition of the local effect of burns. These various degrees are usually found associated to a greater or less extent; indeed, in the more severe cases, the first three or four degrees are almost invariably met with together.

Surgically, the fourth degree is the most important, and most severe burns extend to it. In practice it is difficult, if not impossible, to distinguish between the third and fourth degrees till the sloughs begin to separate. In both the skin is parchment-like and of a brownish yellow colour. The importance of the fourth degree is due to the complete destruction of the whole thickness of the skin, and the consequent extensive granulating and suppurating surfaces that are left; and to the tendency to deformity from the contraction of the cicatrices.

The scars of burns have been credited with some peculiar power of contraction, but there is no reason to believe that the granulation-tissue formed to repair a loss of tissue presents any differences corresponding to the particular injury which caused the mischief. Burns are the injuries in which the largest granulating sores are met with; and, as we have before seen, contraction is an essential part of healing, and the amount is directly proportional to the size of the sore and the looseness of the soft parts.

This process of contraction continues for many months after the sore has become covered with epithelium, giving rise frequently to the most distressing deformities, and to complete loss of motion and use in parts. These cicatrices are composed of dense fibrous tissue, and often extend deeply between and mat together the muscles, vessels, and soft structures of a limb, of the face, or of the neck.

The Constitutional Effects resulting from burns are most serious and important; they depend not so much upon the depth of the injury as upon its situation, the extent of surface implicated, and the age of the patient. Thus a person may have his foot completely charred and burned off by a stream of molten iron running over it, with far less constitutional disturbance and danger than if the surface of the trunk and face be extensively scorched to the first and second degrees; burns about the chest, the head, and the face, being far more likely to be attended by serious constitutional mischief than similar injuries of the extremities. In children, the system generally suffers more severely from burns than in adults. The fever that follows a bad burn is probably due to several causes combined, such as the reaction after extreme primary depression, and the retention in the blood of waste products in consequence of the arrest of the cutaneous secretion in the burnt parts; but the two chief causes are undoubtedly the inflammation produced by the burn and the absorption of the products of putrefaction from the raw surface. Experiment has shown that the charred surface resulting from a burn, so far from presenting a barrier to the entrance of septic matter into the system, as is sometimes supposed, is in reality equal in its power of absorption to a raw surface made with a knife. Unless special precautions are taken, therefore, to prevent decomposition in the sloughs, the amount of septic products absorbed is very large, and the resulting fever proportionally severe.

The constitutional disturbance induced by burns, in whatever degree, may be divided into three stages: 1, Depression and Congestion; 2, Reaction and Inflammation; 3, Suppuration and Exhaustion.

1. The stage of **Depression of the Nervous System and Congestion of Internal Organs,** occupies the first forty-eight hours; during which death may occur. Immediately on the receipt of a severe burn the patient becomes cold and collapsed, and is seized with fits of shivering, which continue for a considerable time. He is suffering evidently from the shock of the injury; the severity of the shivering is usually indicative of the extent of the constitutional disturbance, and is more prolonged in those injuries that occupy a great extent of surface, even though it be burnt only to the first or second degree, than in those which, being of more limited superficial extent, affect the tissues deeply. In many cases of extreme burn the patient suffers no pain although perfectly conscious. This is a very grave sign, indicating the severest shock. On the subsidence of the symptoms of depression, there is usually a period of quiescence before reaction comes on. At this time vomiting is a common and

troublesome symptom, and the patient, especially if a child, not unfrequently dies comatose; death resulting from congestion of the brain and its membranes, with, perhaps, serous effusion into the ventricles or the arachnoid. Besides these lesions, the mucous membrane of the stomach and intestines, as well as the substance of the lungs, is usually found congested.

The pathological phenomena of this period are altogether of a congestive character. Of 15 cases in which the contents of the cranium were examined, I found congestion of the brain and its membranes, with serous effusion, in all; in 14 of these cases the thoracic viscera were found to be congested in 9, healthy in 5; and of 14 in which the abdominal organs were examined, congestion of the gastro-intestinal mucous membrane was found in 12 cases, and a healthy condition in two only.

2. The next stage, that of **Reaction** and **Inflammation**, extends from the second day to the second week. The action of the heat which causes the burn is momentary, and produces its full effect instantaneously. The inflammation which is the direct result of the heat sets in therefore at once, and if no other cause came into play, it would be accurately limited to the part acted on, and begin to subside after the first few hours. This is, however, not the case in the majority of burns. By the end of the second day the inflammation is still increasing in intensity and extent. The burnt area is surrounded by a wide-spreading blush of redness; there are œdema, heat, and pain. With these there is fever proportional to the extent of the burn. It is important to consider, therefore, what is the cause that continues to act, and not only to maintain but to extend the inflammatory process long after the original cause has ceased to exert any influence. In burns accompanied by death of considerable portions of tissue, the presence of the dead matter no doubt causes some irritation in its immediate neighbourhood; but the great cause of the inflammation that occurs during the first week of a bad burn is the decomposition of the adherent sloughs, and the fever that accompanies the process is in great part due to the absorption of the chemical products of putrefaction. It is during this period that a large burn becomes so horribly offensive unless special means are adopted to prevent it. Death, which is more frequent during this stage than in the preceding one, is usually connected with some inflammatory condition of the gastro-intestinal mucous membrane or of the peritoneum. The lungs also are frequently affected, showing marked evidence of pneumonia or congestion; but the cerebral affections are not so common as in the first stage; though, when they occur, they present more unequivocal evidence of inflammation. The following are the results of the *post mortem* examinations which I have made. Of 17 cases in which the contents of the cranium were examined during this period, there was congestion, with evidence of inflammation and effusion of serous fluid, generally stained with blood, in 14; a healthy state in the remaining 3. Of 19 cases in which the lungs were examined, there was congestion of these organs, probably inflammatory, in most instances; with serum or lymph in the pleura, and redness of the bronchial mucous membrane, in 10. The lungs were hepatized in 5, and healthy in 4. The abdominal organs were examined in 22 cases; of these there was congestion of the mucous membrane, sometimes with evidence of peritonitis, in 11; ulceration of the duodenum in 6; a healthy state in 5. The *post mortem* appearances are, in fact, those of acute septic poisoning, possibly complicated in some cases by a genuine infective process.

It is in this stage of burn, that the very remarkable and serious sequela, **perforating ulcer of the duodenum**, is especially apt to occur. Curling, who first attracted attention to it, explained its occurrence by the supposition that Brünner's glands endeavour, by an increased action, to compensate for the suppression of the excretion from the skin consequent upon the burn; and that the irritation thus induced tends to their inflammation and ulceration. This ulceration may, as Curling remarks, by rapidly proceeding to perforation, expose the pancreas, open the branches of the hepatic artery, or, by making a communication with the serous cavity of the abdomen, induce peritonitis, and thus cause death. It usually comes on about the tenth day after the occurrence of the injury; seldom earlier than this. The only exception with which I am acquainted was in the case of a child, nine years of age, who died on the fourth day after the burn, in University College Hospital, and in whom an ulcer, of about the size of a shilling, with sharp cut margins, was found in the duodenum; the intestinal mucous membrane generally being inflamed. That these ulcers are not invariably fatal, is evident from a case mentioned by Curling, in which, on death occurring, from other causes, eight weeks after the injury, a recent cicatrix was found in the duodenum. These affections seldom occasion any very marked symptoms to indicate the nature of the mischief, the patient suddenly sinking. In some instances there is hæmorrhage; though this is not an unequivocal sign, as I have several times seen it happen from simple inflammatory congestion of the intestinal mucous membrane. Pain in the right hypochondriac region, and perhaps vomiting, may also occur.

3. The stage of **Suppuration** and **Exhaustion** continues from the second week to the close of the case. In it we frequently have symptoms of hectic, with much constitutional disturbance from the long continuance of exhausting discharges. If death occur, it is most frequently induced by inflammation of the lungs or pleura; affections of the abdominal organs and brain being less frequent during this stage of the injury. Pyæmia is not uncommon.

Of 7 cases in which the lungs were examined, they were found to be healthy in one only; being hepatized, with effusion into the pleuræ, in the remaining 6 cases. Of 7 cases in which the abdominal organs were examined, a healthy state was found in 4; inflammatory congestion in 2; and a cicatrized ulcer in the stomach in 1. Of 5 of the cases the cerebral contents were found healthy in 1 only; there being inflammatory congestion in the other 4.

Prognosis.—The influence of extent, degree, and situation, on the prognosis of burns has already been stated. The most fatal element indeed of these injuries is *superficial extent*. It is generally believed by Surgeons that recovery cannot take place if one-third of the surface of the body be scorched or burnt. Not only do the cutaneous nerves become greatly irritated, and the nervous system generally suffers severely, from the shock of an extensive burn: but, owing to the arrest of the cutaneous secretion over a large surface of the skin, congestion of the internal organs and of the mucous membranes ensues; hence death may happen directly from this cause, or from the supervention of inflammation in the already congested parts, more particularly in the early periods of life. The *degree* of burn influences the prognosis unfavourably rather so far as the part itself is concerned, than as the general system is affected. The most fatal *period* in cases of burn is the first week after the accident. I find that, in 50 cases of death from these accidents, 33 proved fatal before the eighth day; 27 of these dying before the fourth day. Of the

remaining 17 cases, 8 died in the second week, 2 in the third, 2 in the fourth, 4 in the fifth, and 1 in the sixth.

Mode of Death from Burn.—When in an ordinary conflagration a person is "burnt to death," the fatal event is occasioned not by the charring of the body, but by the induction of asphyxia. Life is mercifully extinguished by suffocation in the smoke and noxious vapours resulting from the fire, before the body itself is consumed. To what particular product of combustion the asphyxia is due, is somewhat undecided. There is reason to believe that in most cases carbonic oxide rather than carbonic acid is the cause of suffocation.

When a person is severely and extensively burnt, and dies in the course of a few hours, or a day or two, death arises usually from shock, which is most severe and continuous. Dupuytren was of opinion that during this stage the sufferer died from the excessive pain, and stated that "too great a loss of sensibility might kill as well as too great a loss of blood." Whether this be so or not, it is perhaps difficult to say; but the fact remains certain that, in individuals who die during this stage, the brain and its membranes will invariably be found congested, usually with more or less effusion of serous fluid into the ventricles and the arachnoid. This I have invariably found in every case that I have examined. In one half of the cases I have found congestion of the thoracic organs, and in the majority congestion of the abdominal organs, more especially of the mucous membrane of the stomach and ileum. Death during the second stage is usually dependent upon internal septic inflammations, more particularly of the gastro-intestinal mucous membrane and lungs, and less frequently of the brain and its membranes. If the patient survive into the period of suppuration, and then succumb, he will usually die from exhaustion or pyæmia.

Treatment.—The treatment of burns must have reference to the constitutional condition, as well as to the local injury. A vast variety of local applications have been recommended by different Surgeons, such as flour, starch, cotton-wadding, treacle, white paint, gum, solution of India-rubber, &c.; the principle of all these applications is, however, the same, viz., the protection of the burnt surface from the air. I shall here content myself with describing the methods that are usually followed with much success at the University College Hospital.

The **Constitutional Treatment** is of the utmost consequence. We have seen how death arises at various periods after these accidents from different causes, and we must modify our treatment accordingly. The first thing to be done after the infliction of a severe burn is to bring about reaction; the patient is trembling in a state of extreme depression, suffering great pain, is cold and shivering, and may sink from the shock unless properly supported. A full dose of liquor opii, varied according to the age, should be given at once in some warm brandy-and-water, and repeated, if necessary, in the course of an hour or two.

When the body is extensively but superficially burnt, the immersion of the patient in a warm bath gives instantaneous relief, assuaging the pain and removing the depression.

When reaction has fairly set in, the patient's secretions should be kept free by the administration of an occasional mild purgative and salines. Should any inflammatory symptoms about the head, chest, or abdomen manifest themselves, it will be necessary to have recourse to treatment appropriate to their nature.

I have certainly seen patients saved in these circumstances by the employment of blood-letting and the application of leeches. But, in the vast majority of instances, the visceral complications are of a low and congestive type. In such cases our great reliance must be on stimulants. Ammonia and bark, brandy and wine, require to be freely given, with a sufficiency of nourishment; and the irritability of the nervous system must be soothed by the frequent administration of full doses of opium. At a later period, when the strength has become impaired by the profuseness of the discharges, this tonic and stimulating plan must be actively continued.

Local Treatment.—In all cases of extensive burn the charred clothes must be removed, and the patient laid upon a blanket and protected as far as possible from exposure to cold. The objects aimed at in the further treatment are the protection of the raw surface, which in all degrees of burn below the fourth is acutely sensitive, the prevention of decomposition, and the exclusion of cold. In burns of the first degree no treatment is necessary; when it is limited to the second degree the blister may be punctured and the serum allowed to drain away, but the cuticle should not be removed. The whole part may then be wrapped in cotton wool and left untouched for a few days, by which time it will have quite recovered. In the third and succeeding degrees of burn, sloughs have to separate and suppuration will take place, and prevention of decomposition consequently becomes of the first importance. The extent of the raw surface, however, and the readiness with which absorption takes place from it, render it unsafe to apply any antiseptic possessing powerful toxic properties, and for this reason the use of carbolic acid is better avoided. Boracic acid, salicylic acid, and eucalyptus oil are the most powerful of the non-toxic antiseptics. Boracic acid may be applied either by means of boracic lint soaked in a concentrated solution of the acid and covered with oiled silk, or as ointment (p. 194) spread on strips of linen. If much sloughing is expected, the former is the better plan; if little, the latter. Salicylic acid may be used as a lotion to cleanse the parts, and the whole burnt area may afterwards be covered by a thick layer of salicylic wool, not to be removed till either high fever or smell suggests that putrefaction is taking place beneath it. Eucalyptus oil may be used either as gauze or as a solution in olive oil. Iodoform may be sprinkled on the surface if the discharge becomes foul, but caution must be used in its application, especially in children, as symptoms of poisoning (p. 195) may arise. In the absence of the necessary material for the above modes of treatment the following plan will be found comfortable to the patient, and satisfactory in its results. The whole burnt surface, whatever may be the degree of burn, may be well covered with the finest wheaten flour by means of an ordinary dredger. The flour should be laid on thickly, but uniformly and gradually; it forms a soft and soothing application to the surface. If the cuticle have been abraded, the flour will form a thick crust, by admixture with the serum discharged from the broken surface. If the skin be charred, the discharge which will be speedily set up around the eschar, will make the flour adhere to the part, forming, as it were, a coating impervious to the air. The crusts thus formed should not be disturbed until they become loosened by the discharges, when they should be removed. In this mode of treatment the decomposition of the discharges is retarded and limited by the dryness of the dressing.

A common remedy in iron-works and other places where burns are common

is the so-called *Carron-oil*, composed of equal parts of linseed-oil and lime-water, to which a small quantity of spirits of turpentine is sometimes added. It is applied on lint. Whatever local application be adopted, I hold it to be of the utmost importance in the early stages of the burn to change the dressings as seldom as possible; if dry dressings are used, not until they have been loosened by the discharges. Every fresh dressing causes the patient very severe pain, produces depression, and certainly retards materially the progress of the case.

When the sloughs have separated, the granulating surface must be managed on ordinary principles. It is important, however, to select some form of dressing that will not stick to the sore, otherwise the granulations may bleed every time it is changed to such an extent as seriously to weaken the patient. To prevent this, the green "protective" oiled silk may be applied directly to the sore and covered with dry boracic lint or salicylic wool; under this plan of treatment the dressing is perfectly painless. If the granulations become prominent they must be touched with nitrate of silver. Epithelium-grafting is often very useful in hastening the healing.

Prevention and Removal of Contraction.—As cicatrization advances,

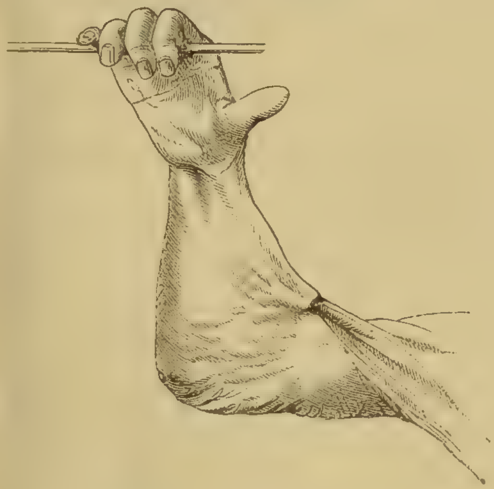


Fig. 123.—Contraction of Elbow from Cicatrix of Burn of Fourth Degree.

Fig. 124.—Contraction of Thumb from Burn of Fourth Degree.

the part must be fixed in a proper position by means of bandages, splints, and mechanical contrivances, specially adapted to counteract the tendency to contraction of the cicatrix, and the consequent deformity. This is especially necessary in burns about the neck, where the chin is liable to be drawn down on the sternum; and in burns on the inside of limbs or at the flexures of joints, more especially the elbow, where contraction greatly impairs the utility of the arm. (Fig. 123.) In bad burns of the hands, the fingers may be drawn into and fixed upon the palm of the hand, may become webbed together, or may be dislocated and fixed immovably against the dorsum. The accompanying woodcuts are good illustrations of the bad effects of burns upon the hands. In Fig. 125, the little finger has been dislocated backwards, and fixed upon the dorsum.

Fig. 125.—Dislocation backwards of Little Finger from Contraction of the Cicatrix of a Burn of the Fourth Degree.

In Figs. 126 and 127, the two hands were frightfully deformed—the fingers being partly consumed, and partly webbed and matted together by dense cicatricial tissues. This accident occurred in consequence of the night-shirt taking fire. The patient tried to extricate himself by drawing the burning garment over his head, but, the wristbands being buttoned, he could not withdraw the hands, which were frightfully burnt. Fig. 126 represents the thumb drawn into such a position as to be no longer capable of being brought into apposition to the fingers.

Similar contractions may occur in the foot, leaving great deformity, as in Fig. 128, where the heel is shown to be retracted, and the whole of the toes

Fig. 126.—Deformity of Right Hand from Burn of the Fourth or Fifth Degree.

Fig. 127.—Deformity of Left Hand from Burn of the Fifth Degree.

spread out in a fan shape. In this case amputation (Pirogoff's) was the only means left for securing an useful limb.

The contracted cicatrices resulting from burns may, if of recent date, be stretched out by the pressure of strips of plaster or elastic bandages, the

Fig. 128.—Deformed Foot from Burn of the Fourth and Fifth Degrees.

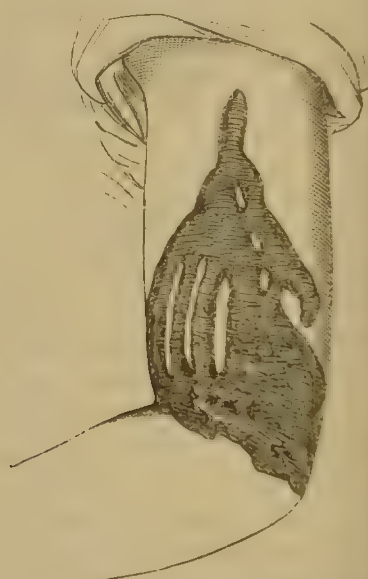


Fig. 129.—Warty Cicatrix of Arm resulting from action of Sulphuric Acid.

traction of India-rubber bands, or the action of rack-and-pinion apparatus. The good effect of this plan of treatment is especially marked in contractions at the elbow, or in those that fix the arm to the side. These means are particularly useful in children, and indeed are so in all cases, provided the cicatrix

be not too old—not more than a year; after that time, it will seldom yield without division.

Corrosive liquids, such as strong sulphuric acid, when applied to the surface, produce effects very similar to those that result from the more severe degrees of burn; leaving cicatrices contracted, irregular, and often, as in Fig. 129, rugged and warty.

Operations for the Removal of the Effects of Contraction consequent upon burns are occasionally required; and, if judiciously planned and executed, may do much to improve the patient's condition. The operations that are practised with this view are of two kinds: 1. Simple division of the Faulty and Contracted Cicatrix; 2. The Transplantation of a flap of adjacent healthy Skin into the gap left after the division of the cicatrix.

1. In the first operation, that of simply **Dividing the Cicatrix**, three points require special attention: 1st, that the division extend completely through the cicatrix from side to side into the adjacent healthy skin; 2nd, that the incision be carried through the whole depth and thickness of the cicatrix into the healthy adipose tissue beneath it, which may always be recognized by its yellow colour; 3rd, that all contracted bands lying in this layer be fairly divided. The great obstacle to the success of this operation, however, consists in the fact that the new granulations, which spring up after the division of the contracted cicatrix, in their turn contract whilst healing. After the division of the cicatrix, also, it may be found that the subjacent structures have been so rigidly fixed in their abnormal position as not to admit of extension. It may then be necessary to employ screw-apparatus, or even to divide fasciæ and tendons, before the part can be restored to its normal shape. Care must, however, be taken in doing this, that subjacent structures of importance, such as large blood-vessels, or nerves, be not so closely connected with the cicatrix as to render wound or division of them unavoidable. In the neck, cicatricial bands will often come into very dangerous proximity to the external jugular vein, which becomes greatly distended by the pressure thus exercised upon it. And at the elbow, which is a common seat of contraction from burns, the brachial artery may become involved in the cicatrix to a dangerous extent. I have heard of one case in which this vessel was divided in cutting through the cicatrix, when amputation of the arm was immediately resorted to.

These operations are most successful in cases of contraction at the flexures of the joints. If the contraction be of very long standing, the arteries and nerves will have become shortened, and incapable of stretching under any force that may be safely employed; hence they may easily be torn.

2. Operations that are undertaken for the removal of the disfigurements that occur about the face and neck as the result of burns, require much management. In these cases, simple division of the cicatrix is insufficient; and **Transplantation of a Flap of Skin** is required in addition. After the cicatrix and all cicatricial bands have been freely divided in accordance with the rules just given, a flap of integument, of sufficient size to fill the greater part of the gap, must be dissected up from the neighbouring parts of the neck, chest, or shoulder, and laid into the cicatrix. There it should be fixed by two or three points of suture; but extreme care must be taken that no traction be put upon it, lest it slough. Union takes place by the second intention in the majority of instances; but a very satisfactory result is left, as is shown by the

annexed figures (130, 131), taken before and after operation, and as has been illustrated in many cases by Mütter and Teale, who have particularly distinguished themselves in such operations. The directions given by Teale for the

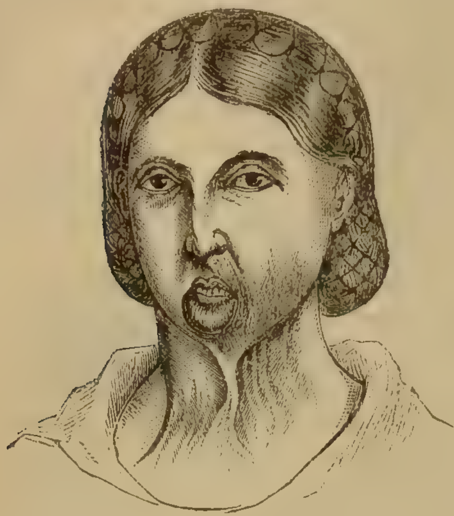


Fig. 130.—Cicatrix of Lip and Neck before Operation.

Fig. 131.—The same Patient after Operation.

restoration of the lower lip when dragged down, everted, and partially destroyed, by cicatrization following a burn, are so simple and lead to such excellent results, that I give them nearly in his own words. The everted lip is divided into three parts, by two vertical incisions three-quarters of an inch long,

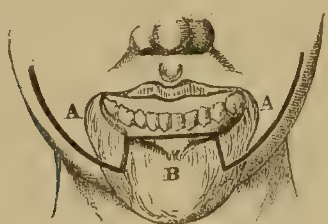


Fig. 132.—Incisions in Teale's Operation for Cicatricial Deformity of the Lower Lip.

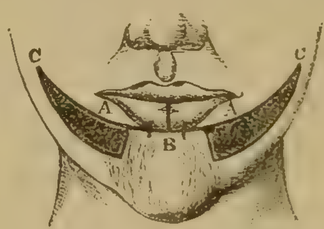


Fig. 133.—Teale's Operation : the Flaps in Place.

carried down to the bone. These incisions are so planned that the middle portion between them (Fig. 132, B) occupies one-half of the lip. From the lower end of each incision the knife is carried upwards to a point one inch beyond the angle of the mouth (A). The two flaps thus marked out are freely and deeply dissected up. The alveolar border of the middle portion is then freshened. The lateral flaps (Fig. 133, C A) are now raised, united by twisted sutures in the mesial line, and supported as on a base by the middle flap, to which they are also attached by a few points of suture, leaving a triangular even surface (C C) to granulate. In addition to the division of the cicatrix, James, of Exeter, in these cases very successfully employed a screw-collar, by which the chin can be loosened from the sternum, and gradual extension of the cicatrix effected.

In severe burns of the side of the face and neck the resulting cicatrix is sometimes so dense, resisting, and contracted, that immobility of the jaw results and the mouth cannot be opened, or at most the teeth can be separated only to a slight extent, so as to admit liquid nourishment. In order

to restore the mobility of the jaw and the power of separating the teeth in these cases, Rizzoli and Esmarch have proposed making a false joint in the lower jaw on the side burnt, immediately in front of the cicatrix. Rizzoli does this by simple division of the bone by means of a narrow saw: Esmarch recommends, as a more effectual procedure, the removal of a wedge-shaped piece of bone about three-quarters of an inch in width above and one inch in width below. After this has been done, the patient will be able to move the jaw at the normal articulation on the healthy side and at the false joint where the jaw has been cut across.

Warty Cicatrices.—The cicatrices of burns, especially on the neck and chest, occasionally become after a time projecting, red, and glazed, as if composed of a mass of fungating granulations, smoothed down and lightly skinned over. This condition, which may be looked on as a substantive disease, and resembles keloid in appearance, has been met with chiefly in children; but I have several times seen it in adults, especially in women who had been badly burnt by their dresses taking fire. In these cases I observed what I have noted in other similar instances in children; that the warty cicatrices were the seat of the most intolerable itching, which no external application seemed to relieve. I have, however, seen the pruritus mitigated by the administration of large doses of liquor potassæ. If small and narrow, these cicatrices may be dissected out: if large, they cannot be removed without risk of much hæmorrhage, for, although fibroid, they are very vascular.

The cause of this peculiar outgrowth of dense cicatricial tissue is altogether unknown. It may in some cases, perhaps, be owing to want of care in checking the luxuriance of the granulations; but in other cases it occurs though every attention is paid to the healing of the wound.

The scars of burns or scalds form the most common seat of this "false" keloid.

The cicatrix of a burn may become the seat of a malignant growth many years afterwards. I have removed a large epithelioma from the cicatrix of a burn, on the fore-arm of a woman, seventy years after the injury had been inflicted, which happened when she was three or four years of age.

Primary Amputation may be required if the burn have destroyed the whole thickness of a limb; the part charred should then be removed at once, at the most convenient point above the seat of injury. This operation may be required also at a later period, if, on the separation of the eschars, it be found that a large joint has been opened, and is suppurating; or if the disorganization of the limb be so great as to exhaust the powers of the patient in the efforts at repair. Great caution, however, should be employed in determining on the propriety of primary amputation when the burn has extended, though in a minor degree, to other parts of the body, lest the powers of the patient be insufficient for the double call that will thus be made upon them.

FROST-BITE.

When the body has been exposed to severe or long-continued cold, we find, as in the case of burns, that local and constitutional effects are produced.

Local Influence of Cold.—This is manifested chiefly on the extremities of the body, as the nose, ears, chin, hands, and feet, where the circulation is less active than at the more central parts. It occurs to an injurious degree chiefly in very young or aged persons, or in those whose constitutions have

been depressed by want of the necessaries of life. In such persons frost-bite and the resulting gangrene are as much due to the habitual low vitality of the extremities as to the low temperature to which they are exposed.

The extreme parts of the body, as the feet, more especially the toes, necessarily suffer most frequently, in many cases from long exposure to wet at low temperatures rather than to dry cold. The fingers, the tip of the nose and chin, and the prominences of the cheeks, are especially apt to suffer from dry cold, more particularly when its effects are much increased by high wind; for it is a well-known fact that extremely low temperatures are borne with impunity so long as the air is calm, as, happily, it commonly is in these circumstances. But if a high wind springs up, the heat of the body is so rapidly carried off, that sudden congelation of exposed parts may ensue. It is remarkable how some parts escape. Thus the eyeball is never, to my knowledge, frozen so long as life remains, and yet it might be supposed that the aqueous humour at least would easily congeal. The eyelids also, thin as they are, commonly escape frost-bite.

The first effect of cold is to cause a contraction of all the involuntary muscular fibre of the part acted on. The small arteries of the skin become so far narrowed that the circulation through the part is completely arrested. It becomes somewhat shrunken and of a dead white colour. In this condition, being deprived of its natural source of heat, it readily becomes frozen if exposed to a sufficiently low temperature. The experience of the production of local anæsthesia by cold teaches us, however, that the tissues may be completely frozen and kept in that state for a minute or more without suffering any injury. If, however, this condition be maintained for a longer time, it is evident that the vitality of the part will be gradually lowered till it is finally completely extinguished. So long as the part is kept bloodless, inflammation cannot manifest itself; but as soon as the vessels dilate on the restoration of the natural heat of the part, inflammatory phenomena occur varying with the degree of impairment of vitality that the part has suffered during its exposure to cold. If it have been completely killed, the blood fails to enter the vessels of the dead part, which consequently remains white and cold till decomposition sets in. If the damage has been short of this, the blood enters the vessels, and all the phenomena of inflammation are developed. If, from the too sudden thawing of the frozen part, a large quantity of blood is admitted at a high degree of pressure, abundant exudation takes place from the damaged vessels, great swelling and tension ensue, and the circulation may again be arrested, partly by the pressure caused by the exudation, which may extinguish such remains of vitality as are left in the tissues, and partly by the obstruction to the circulation within the vessels from adhesion of the corpuscles. Thus a part which had escaped death from the direct action of the cold may rapidly become gangrenous after a short period of apparent restoration. If it escape gangrene the inflammation gradually subsides, often being accompanied by vesication. If the damage done is still less, the restoration of warmth is followed merely by some redness and possibly a little swelling with much burning pain. The effects of cold, in fact, form one of the best illustrations of the facts that inflammation is the direct result of damage of a part to a degree short of causing death, and that the degree of inflammation is proportional to the degree to which the vitality is lowered.

When gangrene results it is most commonly of the moist variety; the part

is swollen and black, finally it becomes dry and shrivelled, and separates by the formation of a line of ulceration around it.

The *Constitutional Effects* of a low temperature need not detain us. It is well known that, after exposure to severe or long-continued cold, a feeling of heaviness and stupor comes on, and gradually creeps on to an overpowering tendency to sleep, which, if yielded to, terminates in coma, and a speedy, though probably painless, death.

Treatment of Frost-Bite.—This consists in endeavouring to restore the vitality of the frozen parts. The great danger is that the circulation may become again arrested, as above described, by the sudden admission of a large quantity of blood at a high degree of pressure. In order to prevent this accident, the temperature must be elevated very gradually and with extreme care. The patient should be placed in a cold room, without a fire, any approach to which would certainly lead to the destruction of the frost-bitten members. These must then be gently rubbed with snow, or with cloths dipped in cold water, and held between the hands of the person manipulating; as reaction comes on, they may be enveloped in flannel or woollens, and a small quantity of some warm liquid or spirit and water may be administered. In this way sensibility and motion will be gradually restored, often with much burning and stinging pain, redness, and vesication of the part. If gangrene have come on, or if the reaction run into sloughing, the sphacelated part, if of small size, should be allowed to detach itself by the natural process of separation, which should be interfered with as little as possible, the vitality of the parts continuing at a low ebb, and extension of gangrene being readily induced. If the gangrenous parts be of greater magnitude, amputation may be required. This should be done at the most convenient situation, as soon as the line of separation has fully formed.

If the person who has been exposed to cold be apparently dead, he must be put in a cold room, the temperature of which must be very slowly raised. Friction, as just described, should be practised, and artificial respiration set up. These means must be continued for a long time, even if no signs of life appear: there being on record instances of recovery after several hours of suspended animation.

Chilblain is a mild form of frost-bite occurring in children and in delicate adults. It occurs on the toes and fingers, and occasionally on other exposed parts, as the nose or ear. It is especially liable to occur in paralyzed or diseased limbs. Most commonly the inflammation does not extend beyond redness and swelling, with burning pain or intense itching. In more severe cases the inflammation of the skin extends to vesication, and occasionally, when the blister bursts, a small slough of the superficial part of the cutis, or in some cases even of its whole thickness, is found beneath. This forms the so-called "broken chilblain."

Treatment.—Very bad chilblains in children, or chilblains of any kind in the adult, are indications of some degree of debility. Healthy exercise, good diet, warm clothing, wash-leather socks, and tonics are useful. Locally, in the simple erythematous stage, the application of tincture of iodine is often recommended, or soap liniment to which a little chloroform has been added. Belladonna and soap liniment in equal parts allays the intolerable itching. If a slough forms, boracic-acid-lint or -ointment forms a useful application. Unguentum resinæ hastens the healing.

CHAPTER XIII.

INJURIES OF BLOOD-VESSELS.

INJURIES OF VEINS.

VEINS are very commonly wounded suicidally, accidentally, or in surgical operations; but, unless they be deeply seated, their injuries are seldom attended by any serious consequences. Occasionally subcutaneous rupture or laceration of a vein takes place from a blow or strain. In such cases extensive extravasation of blood will occur, which, however, usually undergoes absorption in a few weeks; but it may suppurate, or the changes described at p. 295 may take place. This accident is most commonly seen in the internal saphenous vein.

There are three sources of danger in open wounds of veins. 1, Loss of Blood; 2, Septic or spreading inflammation of the vein; 3, Entrance of Air into the Circulation.

1. A vein is known to be wounded, when dark blood flows in a rapid and uniform stream from the seat of injury.

The **Hæmorrhage** from a wounded vein may, if the vessel be superficial, be arrested by position, and the pressure of a compress, with a few turns of a roller. A wound of one of the larger veins of the trunk—as of the vena cava, innominate, or iliac—will necessarily prove rapidly fatal from uncontrollable hæmorrhage. When one of the large external veins is wounded, such as the internal jugular, the axillary, or the femoral, it should be fairly exposed and tied with catgut-ligature above and below the wound in it. Langenbeck has in this case advised that the concomitant artery should also be tied. And *à priori* it might be supposed that this would be a wise precaution. But experience and the result of statistical inquiries have alike demonstrated its fallacy. Gross and Morris have shown that the ligature of the internal jugular when wounded in operations about the neck or in suicidal attempts is a very safe procedure—whilst if the common carotid be ligatured at the same time, the mortality following the double operation becomes very high. In the extremities also the simultaneous ligature of the main vein and artery is especially apt to lead to gangrene.

A small puncture in a large vein may be treated by picking up the wall of the vessel at the injured spot, and applying a ligature, so as to include the opening without completely occluding the vein.

A wound in a vein is closed in different ways according to the size of the opening and the mode of treatment. If the vein be completely divided and a ligature applied, the closure of the vein is brought about in the same way as that of an artery under similar circumstances (see Wounds of Arteries). When a wounded vein is treated by pressure, the lips of the wound come in contact with each other, and union takes place without permanent occlusion of the vessel. If a clot forms above and below the point pressed upon, it is absorbed

and the canal of the vessel restored. At the time when venesection was commonly practised, a patient was often bled many times from the same vein during the course of his life without its becoming occluded.

2. *Septic and spreading inflammation of Veins* will be described when we come to speak of the various forms of venous thrombosis and phlebitis; and 3, the *Entrance of Air into Veins* will be discussed in a subsequent chapter.

INJURIES OF ARTERIES.

Arteries may be bruised, torn, punctured, or cut.

Contusion.—A slight bruise of an artery is not attended by any bad consequences; but, if the contusion be sufficiently severe to damage the coats, the artery may become plugged with an adherent clot, and finally occluded. This clot may be deposited gradually, so that the obstruction of the vessel may not be complete till some days after the accident. Thus, a patient was admitted into University College Hospital under Mr. Quain, with a contused wound in the axilla, received in falling upon some iron railings; no change took place in the circulation of the arm for two days, when pulsation in the radial artery ceased, the injured vessel having evidently become plugged by a clot.

Rupture and Laceration.—An artery may be torn either partially or completely across. When **Partial Rupture** occurs, the internal and middle coats only give way, the toughness of the external coat preventing its laceration. This accident is especially apt to occur in consequence of blows or strains upon diseased or weakened vessels, and may possibly lay the foundation for dissecting and other aneurisms. In other cases, the ruptured portion of the coats becomes turned down into the inside of the vessel, and, acting as a valve, prevents the further progress of the blood through it; more commonly the partially ruptured vessel becomes blocked by a clot adherent to the injured spot. Occlusion of an artery in this way may give rise to gangrene, but as a rule the collateral circulation is sufficient to maintain the vitality of the parts beyond the obstruction.

A similar condition of partial rupture may occur in wounds from blunt instruments. Thus, a case occurred at the London Hospital, in which a suicidal wound of the throat had exposed the carotid artery. After death, it was found that the inner and middle coats of the vessel had been divided by the pressure of the knife, which was blunt, but that the external coat had been left entire; and under this was a dissecting aneurism.

The **Complete Rupture** of an artery may occur either in an open wound or under the integuments. When an artery is torn across in an open wound, as in the avulsion of a limb by machinery, or by a cannon-shot, there is usually but little hæmorrhage, even from arteries of the magnitude of the axillary or the femoral, and though the vessel hang out of the wound, pulsating to its very end. The absence of bleeding is owing to the internal and middle coats, which are fragile, breaking off short and contracting somewhat; while the external coat and

Fig. 134.—Complete Rupture of an Artery.—Vessel laid open. Inner and middle coats broken short, outer coat drawn out.

the sheath of the vessel, being elastic, are dragged down and twisted over the torn end of the artery, so as completely to prevent the escape of blood (Fig. 134).

When the laceration of the artery is subcutaneous, as occasionally happens in the attempted reduction of an old dislocation of the shoulder, the artery is not as a rule completely torn across, and then either extensive extravasation, or one or other of the varieties of *Traumatic Aneurism*, to be described in Chapter XV., may be produced.

In **Penetrating Wounds** of an artery, there is always hæmorrhage of an arterial character, unless the puncture be so fine as to be closed by the mere elasticity of the coats of the vessel. Thus, Maisonneuve has shown that an artery may be punctured with a fine needle, without any hæmorrhage or other unfavourable event resulting. If, however, the puncture be larger than this, being made by a tenaculum or hook, it does not commonly close in this way; and, if hæmorrhage do not take place immediately, it will probably come on in the course of a few hours or days, from ulceration of the vessel. If the wound be still larger, there is always an amount of immediate hæmorrhage proportionate to its size and to that of the vessel.

The *Direction* of the wound in the artery influences materially its characters. If the cut be parallel to the axis of the vessel, there is less tendency to gaping of the edges than if it be oblique. In tranverse wounds of arteries, the retraction of the coats is so great as to cause the wound to assume somewhat of a circular appearance. If the artery be cut completely across, there is always a less degree of hæmorrhage than when it is partially divided; for the retraction and contraction of the cut ends may then be sufficient to close the vessel, whereas they enlarge the aperture when it is merely wounded. When the wound in the artery is subcutaneous, communicating only by an oblique and narrow aperture with the surface, little, if any, external hæmorrhage takes place, but extravasation of blood occurs. The extravasation may either be poured into one of the serous cavities, or it may be diffused in the areolar tissue of the limb or part, infiltrating it deeply and extensively, and perhaps by its pressure ultimately producing gangrene; or it may be effused in a more circumscribed manner, giving rise to one or other of the forms of traumatic aneurism (see Chapter XV.).

HÆMORRHAGE FROM WOUNDED VESSELS.

Local Signs.—The characters of the bleeding or hæmorrhage differ according to the nature of the vessel, from which the blood escapes. When a **Vein** is wounded, the blood that is poured out is of a dark colour, and flows in a uniform stream; the force with which this is projected depending on the conditions in which the wounded vein is placed. If there be any pressure between the wound and the heart, as of a ligature upon the vessel; if the position of the part be such as to favour the gravitation of blood towards the wound; or if the muscles of the limb be made to contract—the force of the flow of blood will be increased.

When an **Artery** is wounded, the blood that escapes is of a bright scarlet colour. It flows by jets, synchronous with the contractions of the left ventricle; between the jets the flow does not cease, but the column of blood falls in height. In the great majority of cases the jet comes only from the proximal aperture, dark blood issuing from the distal opening in a continuous

and trickling stream; but in some situations a jet of blood of arterial character may issue from the distal as well as from the proximal end of the cut vessel, as in wounds of the palmar and plantar arches, or of the arteries of the forearm. As the blood flows, the jet lessens in height, in consequence of the weakening of the heart's action. The height and force of the jet in all cases depend greatly on the size of the vessel; thus the jet from the femoral artery is stronger than that from a muscular branch of the thigh. When a small arterial branch is wounded near its origin from the main trunk, the jet will always be forcible and free; so also the proximity to the centre of the circulation will influence materially the force with which the blood is propelled from the wound in the vessel.

Extravasation.—When the blood is not poured out on the surface, but escapes from a wounded vessel into the areolar tissue of a part, the substance of organs, or internal cavities, it is termed an *Extravasation*. In these cases there are not the ordinary local signs of an external hæmorrhage; but other local phenomena, such as swelling, dulness on percussion, displacement of organs or parts, discolouration of the skin and subjacent areolar tissue, indicate that blood is being poured out subcutaneously; and we judge of the quantity of the blood that has escaped, not only by the extent of these local phenomena, but by the general effect produced upon the system by its loss.

CONSTITUTIONAL EFFECTS OF HÆMORRHAGE.—These depend upon the quantity of blood lost, on the rapidity with which it is poured out, and on the state of the patient's constitution.

When a large quantity of blood is suddenly lost, as when a main artery is cut across or an aneurism bursts, the patient may die forthwith; he falls down in a state of syncope, with a pale cold surface and lividity about the lips and eyes, gasps a few times, sighs, is very restless, and suffers convulsive movements of the limbs before he expires. If the quantity lost be not so great as to produce death, though still very considerable, the patient becomes faint and sick, with coldness and pallor of the surface, profuse perspiration, great restlessness and agitation, thirst, noises in the ears, and failure or complete loss of sight. Although the surface of the body is colder than natural, the patient often complains of feeling hot, and throws off the bed-clothes. The respiration is deep and sighing, and one of the most distressing symptoms is a sensation of want of breath. If the quantity lost, though considerable, be not so great as this, or be spread over a greater interval of time, so that the patient is enabled to rally between the recurrences of the hæmorrhage, a state of anæmia will be induced, characterized by pallor of the skin and of the mucous membranes, palpitation of the heart, rushing noises in the head, a tendency to syncope when in the erect position, œdema of the extremities, and general debility of the system.

After excessive loss of blood the patient may gradually rally, and, as the vital fluid is reproduced in his system, he may recover without any bad effects; or he may fall into a state of anæmia, which may perhaps never be completely recovered from, and may be associated with various forms of local debility and disturbance of functions. After very abundant loss of blood, the pulse often assumes a character which has been termed the "hæmorrhagic pulse." Its frequency is greatly increased, and the wave of the pulse, as felt at the wrist, is much larger than natural, the coats of the artery being relaxed from want of tone, and the vessel imperfectly filled with blood. At the same time there

may be some slight fever. The rallying power is greater in young adults than in old people, and greater in women than in men. Children bear the loss of blood badly—a very small hæmorrhage may induce fatal syncope in infants. In advanced life blood is slowly reproduced ; and a great loss of so complex a fluid, whether by accident or in an operation, is seldom completely recovered from, and predisposes to the development of secondary diseases of various kinds. As has already been stated at p. 16, it is in this way that excessive loss of blood at an operation, as for stone in an aged man, often proves indirectly fatal.

Arterial hæmorrhage is, as a rule, more dangerous than venous, as the loss of blood is more rapid and sudden, and the effect produced is proportionally greater. The body of a person who has died from the effects of hæmorrhage presents a peculiarly blanched, semi-transparent, waxen look ; the lips, alæ of the nose, and finger-nails, have a somewhat livid appearance, contrasting strongly with the clear, yellowish-white hue of the general surface.

Treatment.—The *General Treatment* of hæmorrhage is sufficiently simple. After the flow of blood has been arrested by proper local means, such as will hereafter be described, the effects of its loss are usually speedily recovered from by rest and good nourishment. In some cases, however, the health becomes permanently impaired, and a state of chronic anæmia is induced ; which, notwithstanding the administration of preparations of iron, may continue through life.

When the loss of blood is considerable, it may be necessary to have recourse to immediate measures in order to prevent the syncope from being fatal. With this view the patient should be laid recumbent, with the head low ; and pressure may be exercised upon the abdominal aorta or the main arteries of the limbs, or Esmarch's elastic bandage and tourniquet may be applied, so as to confine the blood as much as possible to the head and trunk, and thus maintain a good supply to the brain and lungs. If death appear imminent from the effects of the hæmorrhage, as happens in some cases of flooding, recourse may be had to transfusion of blood ; the influence of which, in restoring the failing powers of the heart and nervous system, is immediate and most striking, and the value of which has been unquestionably determined by the observations of Blundell and other obstetricians.

Operation of Transfusion.—Although there is reason to believe that Transfusion of Blood was not unknown to the ancients, and the method by which it could be practised was distinctly described by Libavius in 1615, little was done on the subject until Sir Christopher Wren, in 1657, proposed and practised the operation of injecting medicated liquids into the veins of animals. Transfusion was first performed on man in France, by Denis and Emmerets, on June 15, 1667. In November of the same year, it was done in this country by Drs. Lower and King. In the early experiments, the blood of sheep and calves was used. The most extravagant ideas were formed as to the utility of transfusion. It was supposed to be capable of curing diseases by substituting the blood of a healthy animal for that of a diseased person, of removing insanity by the injection of the blood of animals of a gentle and docile character into the veins of a maniac, and of prolonging life indefinitely. These pretensions led to a scientific controversy of the most violent kind ; and some deaths having occurred from the practice, partly in consequence of the rude and imperfect instruments used, transfusion was prohibited in France

and fell into disrepute in England. Although the subject was occasionally revived, little attention was paid to it until about fifty years ago, when transfusion was again practised by Dr. Blundell, who wisely restricted its employment to those cases, occurring chiefly in obstetric practice, in which, in consequence of sudden and profuse hæmorrhage, the patient is threatened with fatal syncope. Dr. Blundell invented a syringe by which the operation might be performed more safely than heretofore ; and by his practice, experiments, and arguments, established the system on a secure basis.

Transfusion is either *mediate* and *indirect*, when the blood is first received in

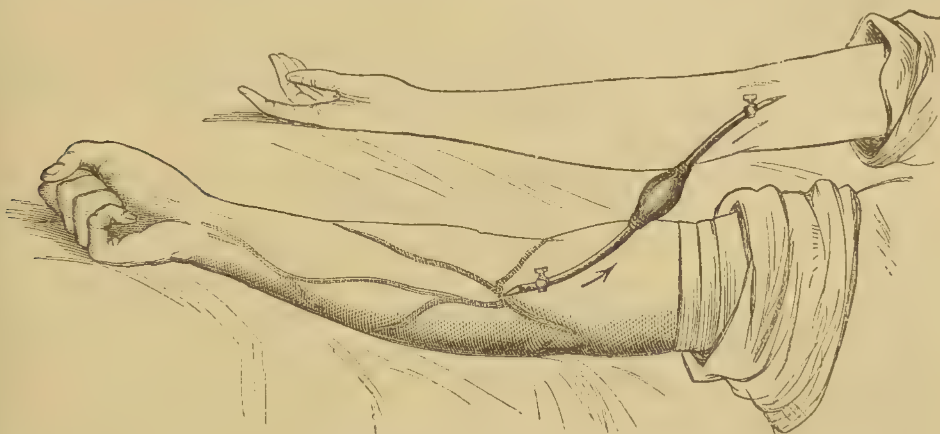


Fig. 135.—Aveling's Method of immediate Transfusion. A, Arm of Donor; B, Arm of Recipient.

a vessel or syringe, and then injected into the veins of the patient ; or *immediate* and *direct*, when a direct communication is established between the vein of the donor and that of the recipient. Until recently the mediate method was almost invariably employed, but this is attended by two sources of danger, which no mechanical provisions are sufficiently accurate entirely to prevent, viz., the introduction of air, and the coagulation of the blood. Dr. Aveling in 1873 introduced a method of immediate transfusion by which these difficulties are to a great extent overcome by the employment of the apparatus which is seen in operation in Fig. 135.

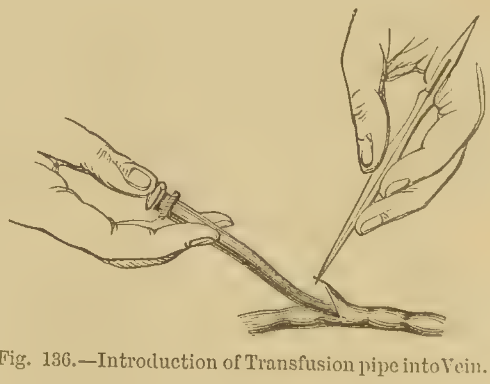


Fig. 136.—Introduction of Transfusion pipe into Vein.

Aveling's transfusion apparatus consists of two silver bevel-ended tubes, one of which is introduced into the vein of the donor, the other into that of the recipient. The vein should be opened as recommended by Aveling, by exposing the vessel, and then making a sharp cut into it (Fig. 136), otherwise it is almost impossible to insert a cannula into the collapsed vein of the recipient. The India-rubber part of the apparatus is filled with warm water, which is retained there by turning the two stop-cocks. It is then fitted on to the tubes in the veins, and the stop-cocks opened. The India-rubber tube on the side of the donor is then compressed, and the bulb slowly squeezed, so as to empty the water which it contains into the recipient vein. The tube on the

recipient's side is then compressed, and that on the donor's opened; the bulb slowly fills with blood, which is then injected by compressing the donor's and opening the recipient's end of the tube, and so alternately until a sufficient quantity is thrown in. Each compression of the bulb throws in three drachms of blood.

In the absence of Aveling's apparatus immediate transfusion can be carried out without difficulty by means of two cannulæ of glass or metal connected by means of an India-rubber tube. The difference in pressure in the veins of the donor and the recipient is quite sufficient to cause the blood to flow through the tube.

A very ingenious but somewhat complicated apparatus was exhibited in this country in 1877 by Dr. Roussel of Geneva. In the hands of its inventor it works admirably, but it is too complicated and too likely to get out of order to be of much practical use.

In case no special apparatus is at hand with which to perform the operation the Surgeon may readily perform the operation of mediate transfusion with an ordinary hydrocele or aspirator syringe, and it is then safer to defibrinate the blood to avoid the accidental introduction of clots into the circulation. Panum, of Copenhagen, has clearly shown by numerous experiments that the fibrin is not in any way necessary to the success of the operation. He recommends that the blood be drawn into a cup kept warm in a basin of hot water. It is then to be well whipped, filtered through a fine cloth, and injected. The most essential part of the blood is the red corpuscles, which are wanted to serve as carriers of oxygen. The removal of the fibrine in this way materially facilitates the operation.

Whatever form of apparatus is used, care must be taken to prevent the accidental injection of air into the vein. The introduction of a mere bubble of air will not cause any serious consequences, although even this should if possible be avoided. All tubes, therefore, and the cannulæ must be filled with water before the apparatus is set to work. If transfusion be determined on, it should not be delayed until the last moment, when the agony of death has already commenced; for then the actions of the nervous and circulatory systems may be so impaired that the patient is no longer recoverable, or, if temporarily so, will speedily relapse and die.

Transfusion has seldom, if ever, been of any material service after serious surgical operations, such as removal of very large and vascular tumours, amputation at the hip, and the like. In these cases the patient is more often perishing from shock than from actual loss of blood; and consequently, transfusion fails to produce much effect. Transfusion is best adapted to very great and sudden losses of blood from small wounds implicating a large vessel or from secondary hæmorrhage.

Other fluids have been used instead of blood, as milk, and saline solutions of various kinds. Thomas and Howe in America, and Meldon in Dublin, have shown that a quantity of freshly-drawn milk, not exceeding $4\frac{1}{2}$ ounces, may be injected without injurious effects. It seems to possess few, if any, advantages, however, over the injection of a properly prepared saline solution. Some cases have lately been published by Jennings and Coates (*Lancet*, 1882), in which this treatment has been very successfully adopted in post-partum hæmorrhage. The solution used was that recommended by Little in the treatment of cholera by saline injections into the veins, and was composed

of the following:—Chloride of sodium, 50 grains; chloride of potassium, 3 grains; sulphate of soda and carbonate of soda, of each 25 grains; phosphate of soda, 2 grains; water, 1 pint. The solution should be of a temperature of from 98° to 100° Fahr. Whatever fluid be injected, whether blood, milk, or the saline solution, the quantity must be regulated by the effect. A few ounces will usually be found sufficient.

CHAPTER XIV.

ARREST OF ARTERIAL HÆMORRHAGE.

The arrest of arterial hæmorrhage is perhaps the most important topic that can engage the Surgeon's attention, for on the safe accomplishment of this the success of every operation is necessarily dependent. In studying this subject we must first investigate the Means that are adopted by Nature for the Suppression of Hæmorrhage ; and, secondly, the imitation of these by Surgical Art.

NATURAL ARREST OF HÆMORRHAGE.

The history of the investigations into the means adopted by nature for the arrest of hæmorrhage is full of interest to the Surgeon, and is excellently given in Dr. J. F. D. Jones's work on Hæmorrhage. No subject in surgery affords stronger evidence of the advantage of the application of "Experimental Pathology" to practice, than this, as our knowledge of it has been wholly gained by experiments on the lower animals ; and by the sacrifice of the lives of a few dogs, donkeys, and calves, those of hundreds—probably of thousands—of human beings are annually preserved.

Petit, who published several memoirs on this subject in 1731 and following years, states that hæmorrhage is arrested by the formation of two clots—one outside the vessel, which he calls the "*Couvercle*," or Cover ; the other inside, the "*Bouchon*," or Plug—the first being formed by the last drops of blood that issue, the second by the few drops that are retained. These clots by their adhesion to the internal coat of the vessel and to the orifice, he says, stop the bleeding. When a ligature is applied, a similar clot forms above it. He recommends compression, and the support of the clot.

Morand, in 1736, added much of interest. He admitted the formation of coagula, but insisted on the importance of the changes in the artery itself : which, he showed, became corrugated, contracted, and retracted. Morand entertained erroneous views as to the structure and functions of arteries, but he established the great fact that changes occur in the artery itself. Sharp, in the second edition of his work on Operative Surgery, published in 1739, supported the same doctrine.

Kirkland, in 1763, wrote an excellent treatise on the subject. He showed that hæmorrhage was lessened by swooning, and that an artery contracted up to its nearest collateral branch ; and he was of opinion that the coagulum did not arrest the bleeding. His views were adopted and supported by White, Gooch, Aikin, and other surgeons of his day.

J. Bell took a retrograde step by denying the retraction and contraction of the artery, and the importance of the internal coagulum, and by attributing the arrest of hæmorrhage solely to the injecting of the surrounding areolar tissue with blood.

It was not until 1805, that Dr. Jones, by a series of admirably conducted investigations, finally determined the mode in which the arrest of hæmorrhage takes place. Since his time but little has been added to our knowledge of the subject, so complete and exhaustive was his examination of it.

The *Natural Arrest of Arterial Hæmorrhage* is effected by means that in the first instance are *temporary*, but afterwards *permanent*.

TEMPORARY MEANS.—The means which arrest temporarily the flow of blood from an artery are threefold. If the vessel be small, as the facial or radial, these means are sufficient in many cases to stay the hæmorrhage without the interference of the Surgeon ; and, whatever be the size of the vessel, his operations are materially assisted by the efforts which nature makes, though they may be sometimes unsuccessful, to prevent a fatal escape of blood. They consist in :

1. The Coagulation of and an Alteration in the Constitution of the Blood ;
2. A Diminution of the Force of the Heart's Action, and consequently of the pressure on the inner coat of the vessel ;
3. Certain Changes effected in and around the Artery.

1. The **Coagulation of the Blood** in and around the wounded artery is the most important means adopted by nature for the arrest of hæmorrhage. Were it not for the property of coagulation possessed by the blood, that fluid would continue to drain away from any cut artery, however small, until life became extinct. But the coagulation of the blood is sufficient of itself in all arteries below a certain size, to close the opening in the vessel, and so to arrest the further escape. The *Alteration that takes place in the Blood*, as was first pointed out by Hewson, consists in an increase of its coagulability as it flows.

2. The **Diminution in the Force of the Heart's Action**, owing to the patient becoming faint, exercises a very material influence in arresting the flow of blood from an artery. The forcible manner in which the jet of blood is propelled at each systole of the ventricle, is the principal obstacle to the formation of an adherent blood-clot around and within the cut vessel ; for so long as the jet is more powerful than the cohesion of the clot, it will certainly wash the coagulum away. As the blood flows, and the heart's impulse gradually lessens in force, the jet falls lower and lower ; until at last, when faintness comes on, it is almost entirely arrested, and time is afforded for the formation and the deposit of a coagulum in the vicinity of the wound. The collapse consequent on excessive and sudden loss of blood may therefore be looked upon as one of the provisions of nature for the safety of the patient, and should therefore not be too speedily counteracted by stimulants or in any other way.

3. The **Changes that take place in and around the Vessel itself** are those upon which the final arrest of the bleeding is dependent. They consist in the *Retraction* of the artery within its sheath, in the *Contraction* of the cut ends, and in the *Formation of a Coagulum* around its exterior, and in its interior.

When an artery is cut across its longitudinal elasticity causes it immediately to *retract within its sheath*, and at the same time its orifice is narrowed by *the contraction of the muscular fibre-cells of the middle coat* in consequence of the stimulation of the mechanical violence. As the artery retracts the interior of the sheath is left rough and uneven. Through this

uneven channel the blood is projected, either flowing away freely externally or being extravasated into the neighbouring areolar tissue, according to the direction and state of the wound. As the blood flows over the roughened surface of the sheath, it becomes entangled in the fibres, and tends to coagulate upon them; this tendency to coagulation is favoured by the increased plasticity of the blood as it flows, and by the diminution of the propulsive force with which it is carried on. By the conjoined operation of these causes a coagulum is formed, which, though lying within the sheath, is outside the artery, and extends beyond it; and is hence termed the **external coagulum**. It is usually somewhat cylindrical, and often looks like a continuation of the vessel, being at first perforated by a hollow track, through which the stream of blood continues to flow. As it increases in size, the hollow becomes closed by the concentric deposit of coagulum. The hollow track leading from the surface of the coagulum to the wound in the artery, has been especially described and dwelt upon by Amussat. This coagulum acts mechanically by blocking up the end of the artery, and thus constitutes the first barrier to the hæmorrhage. The formation of the external coagulum thus greatly favours the retraction of the artery within its sheath.

Simultaneous with the changes that have just been described is the **contraction** of the cut artery which commences immediately after its division, and may of itself be sufficient to close a small vessel. Thus, during an operation, we may often see the mouth of an artery which, when first cut, spouted out a stream of blood as large as a straw, gradually diminish in size until it ceases to bleed, owing simply to this contraction. In a larger artery this process is not sufficient to completely close the vessel, but merely gives its cut end a conical shape, greatly diminishing the aperture in the artery, perhaps to the size of a pin-hole.

The next change that takes place is the formation of the **internal coagulum.** As the open end of the artery becomes obstructed by its own contraction and by the formation of the external coagulum, the blood is propelled with more and more difficulty through it, escaping in a small and feeble stream, and at last becoming completely stationary. Coagulation then takes place within the artery, and the clot that is formed in this situation plays an important part in the permanent closure of the vessel. The internal coagulum is conical in form, the base being firmly adherent to the injured coats of the artery at the margin of the aperture and the apex extending upwards. It has no point of attachment except by its base, the apex and sides being perfectly free; at first it consists merely of ordinary blood-clot, but later on, as will be seen hereafter, important changes occur within it. The importance of the internal coagulum as a temporary means of arresting hæmorrhage, though great, has, I think, been overestimated. In fact it is not formed at all until the flow of blood has been arrested by the contraction of the artery and the formation of the external clot; and in some cases the proximity of a collateral branch to the cut end of the vessel appears, by preventing the stagnation of the blood, to prevent its formation altogether. When it is formed, it is useful in acting as a damper to break the force of the wave of blood against the cut end of the vessel. The contraction of the artery being due to the action of the muscular coat, must necessarily cease before long, when relaxation of the muscular fibre-cells takes place; but by this time the vessel is surrounded externally by a coagulum between the sheath and the external coat.

This clot having been moulded to the artery in its contracted state prevents the dilatation that would otherwise occur.

After the hæmorrhage from the cut artery has been arrested temporarily by the means that have been indicated, Nature proceeds to secure the vessel by permanently occluding it.

Permanent Closure of a cut artery is effected by processes analogous to those which have been already described as occurring in the union of wounds in the Chapter on the Process of Repair (page 268). During the first few hours after the arrest of the bleeding, the internal coagulum contracts slightly and becomes more adherent to the inner coat of the artery. For the first twenty-four hours or more the ordinary process of exudation with migration of the white corpuscles takes place, both from the vessels in the injured coats of the artery and from the vasa-vasorum in the sheath. By the second day therefore we find that the base of the internal coagulum and the external coagulum in the sheath have become paler in colour from infiltration with migrated leucocytes ; and exactly opposite the divided end of the artery there may be a small nodule of colourless plastic exudation, composed entirely of migrated cells held together by coagulated fibrin. This change therefore corresponds to that which has already been described as occurring in the early stages of union of wounds by first intention, the only difference being in the presence of the great excess of blood-clot. By the end of the first twenty-four or thirty-six hours, if all goes well, the process of the traumatic inflammation resulting from the wound and the accompanying exudation should have ceased, and we then have a firm mass of plastic exudation plugging the mouth of the artery and surrounding its cut extremity externally, and the processes of genuine repair now set in. Outside the vessel these consist merely of the vascularization of the "plastic exudation," the absorption of the blood-clot, and the gradual development of cicatricial fibrous tissue, as already described (page 273). It is evident that if these processes go on healthily and undisturbed by further inflammation and exudation, the orifice of the wounded vessel is from the first surrounded externally by a firm substance—first, blood-clot ; secondly, plastic exudation or "coagulable lymph ;" thirdly, firm vascular granulation-tissue ; and, lastly, fibrous scar-tissue. The artery is therefore sealed externally as well as internally, and these external changes are of equal importance with those about to be described as occurring inside the vessel. If inflammation and suppuration take place in the wound from any cause, more especially if decomposition of the discharges sets in with breaking down of the external coagulum, thus causing the presence of septic matter in immediate contact with the end of the wounded artery, the injured vessel is no longer supported externally, and the whole safety of the patient will depend upon the changes occurring within the vessel.

We have already seen that that soon after its formation the base of the internal coagulum becomes infiltrated with exudation from the vessels of the injured coats of the artery, and consequently becomes paler in tint than the rest of the clot. The internal coagulum gradually extends further from the injured part of the vessel till, as a rule, it reaches the next branch above. The next change observed in the clot is that it shrinks slightly. The artery also continues to contract, firmly embracing the coagulum. The clot now becomes firmly adherent in every part to the inner coat till some difficulty may be experienced in separating it. The contracted vessel usually assumes a

conical shape; but in some cases I have seen the contraction commence suddenly, the narrowed part being perfectly cylindrical for about an inch. The next change observable is the *decolourization of the clot.* This commences at the part which is in contact with the injured end of the vessel and gradually extends upwards. The red corpuscles in the clot break up and are absorbed, leaving a firm fibrinous plug closely adherent to the inner coat of the artery. This process of decolourization is accompanied by still further shrinking of the clot. It is usually completed in about a week. The ultimate changes consist in a gradual absorption of the internal coagulum, with development of cicatricial fibrous tissue for a greater or less distance from the divided end, the artery being for a corresponding distance converted into a dense fibrous cord. In some cases the complete obliteration of the vessel reaches as high as the next branch; but in others an extremely narrow channel may be found extending some distance into the contracted part of the vessel.

If these processes be followed microscopically in specimens obtained at different periods from animals, the following appearances may be observed. The first exudation which forms at the cut end of the artery and infiltrates the base of the clot differs in no respect from the early exudation in union of a wound by first intention; it is composed of migrated white corpuscles entangled in the meshes of coagulated fibrine. This exudation commences immediately after the injury. By the third day the base of the clot will be more extensively decolourized and the microscope shows that this is due to the growth of new cells which have occupied the place previously filled by the lower part of the clot. The origin of these new cells has been a matter of dispute. Those which infiltrated the base of the clot in the first twenty-four hours are undoubtedly migrated corpuscles; but it seems probable that as soon as the artery has recovered from the damage done it by the wound, growth commences from the endothelial cells of the inner coat. These are described by Cornil and Ranvier as multiplying rapidly and penetrating into the substance of the clot in bud-like processes. Whatever the source of the new cells may be, this much is certain: that by the end of a few days the endothelium can no longer be recognized at the part where they are growing, and the new tissue replacing the clot is in direct contact with the elastic layers of the inner coat. The mass of cells thus formed is soon penetrated by new vessels springing from the vasa-vasorum of the artery at the wounded part. The further course of development is identical with that already described in the Chapter on Repair, as occurring in the conversion of vascular "granulation-tissue" into cicatricial fibrous tissue. The final result of the process is that the lumen of the artery for a variable distance becomes filled with fibrous tissue continuous with the coats of the vessel. The development of the cicatricial tissue from the granulation-tissue is necessarily accompanied by considerable contraction, while at the same time the muscular coat atrophies from want of use; and thus at the end of some weeks or months the end of the artery becomes converted into a thin cord of fibrous tissue, which becomes lost in the scar of the external wound.

This development of fibrous tissue in the site of the clot has been described as "organization of the thrombus," but this term is somewhat misleading: there is no objection to using it, however, if it be clearly understood what is meant by it. A recent thrombus is composed of coagulated fibrine entangling in its meshes vast numbers of red corpuscles and a few white. It is not now

supposed by any pathologist that the fibrin or the red corpuscles can take any part in the formation of new tissue. The whole question, therefore, turns upon the fate of the white corpuscles in the clot, and, as in the first few hours after its formation the base becomes infiltrated with wandering cells, this question becomes merged into the wider one of the part played by migrating leucocytes in the formation of new tissue. (See Repair.)

O. Weber has described in the vascularization of the thrombus the formation of vessels communicating with the lumen of the artery ; but subsequent observers have not confirmed his views. It is probable, however, that when restoration of the channel of an artery takes place after it has been tied in its continuity with an absorbable ligature—an accident that has occurred more than once—the first channel of communication from above the ligature to below may be by means of the new vessels formed in the thrombus during organization, and that by the subsequent dilatation of these with absorption of the new tissue round them the lumen may be completely restored.

The internal changes above described as taking place in the healthy closure of a wounded artery occur first at the injured extremity of the vessel, the complete closure and obliteration not taking place as high as the next branch till many weeks after the actual divided end is closed and sometimes not occurring at all. During the early period, the upper part of the internal clot serves the important function of breaking the force of the wave of blood and thus giving the necessary rest to the point at which repair is going on. In order that healthy closure of the vessel may take place it is essential that there shall be an absence of undue irritation at the cut end. If the end of the artery is exposed to direct contact with decomposing blood-clot or discharges, inflammation and exudation will continue, and, instead of the firm new tissue sealing the divided end of the artery, excessively soft granulation-tissue or merely puriform exudation may be formed ; and as under these conditions the external support, as before stated, is also wanting, the safety of the patient depends merely on the adhesion of the blood-clot higher up, and secondary hæmorrhage is very likely to occur. A large ligature soaked in septic matter or a decomposing piece of catgut in contact with the injured part of the artery acts as an irritant, prolongs exudation, and softens the reparative material. On the other hand carbolized catgut or silk in an aseptic condition seems to cause little or no irritation beyond that caused by the mechanical violence used in its application.

The changes that have just been described are those which take place in the proximal end of the artery. In the distal or inferior end, occlusion is effected by processes essentially the same, but the retraction and contraction of the vessel are not so complete and extensive, and the coagulum is usually smaller both inside and outside ; in some cases, indeed, the internal coagulum is deficient. The less perfect closure of the distal end may, as Guthrie suggests, be the cause of the more frequent occurrence of hæmorrhage from it.

Arrest of Hæmorrhage from a Punctured or Partially Divided Artery is effected in a somewhat different manner from that which has just been described, the difference consisting in the changes that go on in the neighbourhood of the wound. If the wound in the soft parts covering the artery be of small size and oblique in direction, so that the blood does not escape with too great facility, it will be found that the temporary arrest of the hæmorrhage takes place by an extravasation of blood occurring between the

artery and its sheath, by which the relations between the wound and the aperture in the sheath are altered. The direct effect of the injury is to cause some contraction of its muscular coat, and thus the blood finds its way readily between the sheath and the external coat, and the stratum of coagulated blood extends for some distance within the sheath, above and below the wound, opposite to which it is thicker than elsewhere. Coagulum may likewise be formed in the tissues of the part outside the sheath, by which the tendency to the escape of blood further lessened.

The permanent closure of the puncture is effected by processes analogous to those which take place in repair of other tissues. If the wound be small and well closed by an external coagulum, and if the force of the heart be not too great, the opening may be closed without complete obliteration of the artery. A small layer of clot may form internally, adhering to the wound in the inner coat. Exudation then takes place from the vessels of the external coat and from the sheath externally, and after this follow the ordinary processes of "vascularization of the plastic exudation," and development of fibrous tissue. Thus a small fibrous cicatrix is formed in the wall of the vessel. More commonly the clot gradually increases in size, till the lumen of the vessel is filled up opposite the wound, and then the subsequent changes described above as occurring when an artery is divided take place, and the vessel is permanently obliterated and converted at the seat of obstruction into a fibrous cord. In order that the wound in the artery should unite simply by the formation of a cicatrix in the coats, without obliterating the cavity of the vessel, it is necessary that it be below a certain size; but this size will vary according to the direction of the wound. If this be longitudinal or slightly oblique, it will be more likely to unite in this way than if transverse. Guthrie states that, in an artery of the size of the temporal, a small longitudinal wound may sometimes heal without obliteration of the vessel, though this very rarely happens in larger arteries. If a large vessel, such as the femoral, be opened longitudinally to the extent of one-fourth of its circumference, there is no proof that the wound can heal without obliteration of the cavity of the artery; but when a longitudinal wound in a large artery is very small, little more than a puncture, closure may possibly take place simply by its cicatrization; but the artery always continues weak at this point, and may eventually become aneurismal.

If an artery of the second or third magnitude, as the axillary or femoral, be divided to one-fourth or more of its circumference, either fatal hæmorrhage or the formation of a traumatic aneurism will take place, according to the size and more or less direct character of the external wound.

SURGICAL TREATMENT OF ARTERIAL HÆMORRHAGE.

The object of the Surgeon, in any means that he may adopt for the suppression of arterial hæmorrhage, should be to imitate, or assist the natural processes, or to excite analogous ones.

The danger from arterial hæmorrhage, and the measures that must be adopted to meet it, vary according to the size of the vessel. In all circumstances the Surgeon should bear in mind the excellent advice given by Guthrie, never to fear bleeding from any artery on which he can lay his finger, digital pressure readily controlling bleeding from the largest vessels, provided it can be fairly applied; or the cut end of the artery may be seized between the finger

and thumb. Thus, in amputation at the hip and shoulder-joints, the assistant readily controls the rush of blood from the femoral and axillary arteries by grasping them between his fingers. Above all, the Surgeon should never dread hæmorrhage, nor lose his presence of mind when it occurs. If recourse be had to proper means, it can always be, at least temporarily, arrested. On no account should anyone who pretends to the character of a Surgeon employ inefficient means to stop it, and imagine that he can, by covering up the wound with rags, handkerchiefs, &c., prevent the escape of blood. These procedures only hide the loss that is going on, and, by increasing the warmth of the parts, prevent the contraction of the vessels, and favour the continuance of the bleeding. Under all circumstances, therefore, bleeding wounds should be opened up, the coagula gently removed from their surface by means of a piece of soft sponge or a stream of cold water, and the part well cleaned. In this way "you look your enemy in the face," and can adopt efficient means for the permanent arrest of the hæmorrhage.

The methods of controlling the flow of blood temporarily by digital compression and by the various forms of tourniquet have been fully described on p. 40, *et seq*. It is usually necessary to adopt some of these during the application of means intended to produce permanent arrest of the bleeding. The screw tourniquet and digital compression will usually be found the most convenient, as the pressure can be rapidly relaxed, in order to guide the Surgeon to the bleeding point, and re-applied if necessary.

The different means that may be employed for the *permanent* arrest of hæmorrhage are :—1, the Application of Cold ; 2, the Application of Hot Water ; 3, Styptics ; 4, Cauterization with a Hot Iron ; 5, Pressure ; 6, Flexion ; 7, Torsion ; 8, Forcipressure ; 9, Ligature ; and 10, Acupressure.

1. Application of Cold is sufficient to arrest the general oozing of arterial blood which is always observed on a cut surface. The mere exposure to the cold air of a wound, which has bled freely so long as it has been covered up by pledgets and bandages, is often sufficient. When this does not succeed, the application of a piece of lint, soaked in cold water, will usually arrest the flow of blood. When it is necessary to do this speedily, as in some operations about the air-passages, a small stream of cold water may be allowed to drip into the wound, and thus cause rapid contraction of the vessels, and consequent cessation of bleeding. In cases of bleeding into some of the cavities of the body, as the rectum, vagina, or mouth, the application of ice is advantageous. Its use should not, however, be too long continued, lest sloughing occur. Indeed, if cold do not speedily, almost at once, arrest the bleeding by constricting the vessels, it is better to have recourse to other and more efficient means.

2. The Application of Hot Water is a most valuable means of arresting oozing during or immediately after an operation. It is especially useful in operations about the face and trunk in which it is impossible to adopt any bloodless method of operating, and yet in which it is important that the view of the operator should not be obscured by persistent oozing of blood. It immediately arrests the free bleeding from small vessels which follows the removal of Esmarch's bandage. This mode of treatment was introduced in America in 1879 by Hamilton, Brown, and Hunter. Hamilton applied water at a temperature of between 150° F. and 160° F., by means of sponges held in forceps. Brown recommended washing the whole wound with water of the same temperature.

Hunter applied the water at a lower temperature, 125° F. to 130° F., which can just be endured by the Surgeon's hands. All these plans act very well, and although the heat is sufficient to whiten the surface of a divided muscle, no evil consequence results, and union by first intention is not interfered with. If the wound is being treated antiseptically, a hot solution of carbolic acid, 1 in 40, or two teaspoonfuls of tincture of iodine added to a pint of water, may be used instead of the simple hot water. Care must be taken, in employing this method of arresting hæmorrhage, that the water used be sufficiently hot, otherwise the effect will be merely to increase the bleeding.

3. Styptics are substances which cause contraction of the vessels and coagulate the albumen of the blood, and thus increase the rapidity of formation and the firmness of the coagulum. They are used principally in oozing from spongy parts, or in bleeding from cavities or organs to which other applications cannot readily be made. The great objection to their employment in some wounds is their tendency to modify injuriously the character of the surface, and to prevent union by the first intention. The most useful styptics are the solution of perchloride of iron, spirits of turpentine, and gallic or tannic acid; the application of alum, or touching a bleeding part with a pointed stick of the nitrate of silver, is also serviceable. Of all these, the solution of the perchloride of iron, when applied to a bleeding part, acts as the readiest and most efficient hæmostatic, coagulating the blood with remarkable rapidity, and into a very firm clot. *In order to apply this or any other styptic effectually, the part should be wiped dry, and all coagula removed.* A piece of lint or absorbent cotton-wool, or a sponge squeezed as dry as possible, is then firmly pressed on the bleeding spot by an assistant, or by the Surgeon with his left hand, while another piece of lint or cotton-wool is soaked in the styptic solution, and then squeezed nearly dry. This must be held by the Surgeon in his right hand either in a pair of forceps or in his fingers. When all is ready, the piece of dry lint or sponge which has been pressing on the bleeding surface is rapidly removed, and the styptic instantaneously applied, before the surface has had time to get wet with blood. It may then, if necessary, be maintained in position by the pressure either of the finger or of a pad and bandage. When the hæmorrhage is from a cavity and the actual bleeding point cannot be seen, the styptic solution may be injected by means of a syringe, or, in some cases, if it proceed from a mucous canal, this may be firmly plugged with lint soaked in the styptic solution.

4. Cauterization by means of the red-hot iron was almost the only mode of arresting arterial hæmorrhage that was known to the ancients. It is now comparatively seldom employed, and should never be made use of when less severe measures are likely to succeed. Yet in some cases it is of the most unquestionable utility, and superior to any other means that we possess; more particularly in those cases in which the hæmorrhage proceeds from a soft and porous part that will not hold a ligature, or on the surface of which many points appear to be bleeding at the same time. A somewhat conical iron of sufficient size should be used, and the hæmorrhage will often be staid more effectually if it be applied at a black, than at a red or white heat. The bleeding surface must be carefully dried by the pressure of a sponge or of dry cotton wool before the cautery is applied, otherwise its action is extremely uncertain. It is more useful, perhaps, for the arrest of capillary than of arterial hæmorrhage, but arteries of moderate size may thus be closed. As the actual

cautery blocks up the artery by a thick slough or eschar (Fig. 137), there is always some danger of a recurrence of the bleeding when it separates, and the Surgeon must be on his guard about the sixth or eighth day lest the hæmorrhage break out afresh.

In some cases, however, in which the cautery has been experimentally applied to the cut end of an artery removed from a fresh dead body, it has been found that the eschar is formed of the charred and shrivelled external coat only, the inner and middle coats being separated and turned up into the lumen of the artery. This result, however, does not seem to be constant.

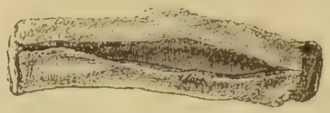


Fig. 137.—A fresh Artery from the dead body, cauterized—showing the firm adherent eschar.

The actual cautery has been frequently employed of late years during operations on very vascular parts in which temporary arrest of the circulation is impossible. It has been used chiefly in two ways: first as the galvanic écraseur, and secondly as a red-hot knife. The galvanic écraseur is simply a loop of platinum-wire which can be heated by electricity after being passed round the part to be removed. During the operation the loop is gradually tightened, by a screw in the handle of the instrument, until the part is removed. Operations performed in this way are almost bloodless; but the instrument, with its battery, is very cumbersome, its action is not certain, and secondary hæmorrhage is common after its use; consequently it is now but little employed. Its place has been taken by Paquelin's red-hot knife. This is a flattened hollow blade with blunt edges, made of platinum, and fixed on a handle connected by an India-rubber tube with a bottle containing benzol. The knife is first made red-hot in a spirit lamp, and its heat is maintained by blowing a mixture of air and benzol-vapour into the hollow blade by means of an elastic ball. The benzol-vapour burns without flame, and the heat can be maintained at any point that is required by driving in a larger or smaller amount of vapour. Care must be taken not to allow any of the liquid benzol to get into the tube, or a flame would flash from the instrument; this is best avoided by filling the bottle with pieces of sponge. The blade can be replaced, if necessary, by cauteries of various shapes. In removing very vascular growths, such as an epithelioma of the vulva, the knife, if at a glowing red heat, arrests the flow of blood from the smaller vessels, only leaving the larger arteries spouting from a perfectly dry surface, and they can thus be seized and tied without difficulty, or, if preferred, touched with the cautery at a dull-red heat. The surface left is very superficially charred, and heals with little or no sloughing. If it be desired to arrest the flow of all vessels completely, the knife must be used at a dull-red heat; it then cuts more slowly and chars more deeply.

5. Direct Pressure upon the bleeding part is a very efficient mode of arresting hæmorrhage from small arteries. It is not, however, applicable to all parts of the body, as it is necessary that the vessel should have a bone subjacent to it, so as to afford a point of counterpressure; hence it cannot readily be employed in soft and movable parts, as the throat or perinæum. Pressure may be practised in various ways. Sometimes the uniform compression of a bandage is sufficient to arrest the hæmorrhage; thus oozing from a wound may often be stopped by laying down the flaps, and applying a bandage rather tightly over them. Sometimes a weight applied upon this—as, for instance,

by means of a shot or sand-bag laid upon the part—will tend still further to arrest the bleeding. In the case of bleeding from hollow cavities, as the rectum, vagina, or nares, the hæmorrhage may be arrested by the pressure of a plug of sponge or lint, to which sometimes a styptic may advantageously be added. When the hæmorrhage proceeds from the puncture of a small or moderate-sized artery, as the temporal, pressure should be made against the adjacent bone by means of a graduated compress and bandage, and should be continued until a sufficient time has elapsed for the vessel to be firmly plugged on each side by an adherent coagulum. The *graduated compress* should be at least an inch in thickness, and made of a series of pledgets of lint of a circular shape, gradually diminishing in size. It should be applied with its pointed end resting over the wound in the vessel. In applying it, care should be taken that the part on which the pressure is to be exercised has been thoroughly dried of all blood, and that the artery is commanded above the wound by a tourniquet, or by the pressure of an assistant's fingers. A thick slice of a phial-cork, or a fourpenny piece, wrapped in lint, being placed on the wound, the graduated compress should be bandaged tightly over the whole. When applied in this way, pressure acts by encouraging the formation of an adherent clot on each side of the part of the vessel closed by the force applied. The subsequent changes are the same as those already described as occurring after spontaneous arrest of bleeding (page 397).

Whenever pressure is used to arrest arterial bleeding, it must not be forgotten that if it is applied, as it must be to be of any use, with sufficient force to arrest the flow of blood through the wounded artery, it must equally empty all the capillaries and veins, thus rendering the whole area pressed upon absolutely bloodless. We have before seen (page 162), that if a part be deprived of blood for a sufficient time in the human subject, probably for between twelve and twenty-four hours, the re-admission of blood is accompanied by all the phenomena of acute inflammation, the intensity of the process varying with the length of time during which the part has been left bloodless; and we are all of course familiar with the fact that, if the pressure be applied with sufficient force for a sufficient length of time, death of the part must follow. It is very important, therefore, that pressure should not be applied for a single hour longer than is necessary to ensure the safe plugging of the wounded artery by an adherent clot. The experience of acupressure has shown us that in a small artery—and it is, of course, only to small arteries that pressure is applied as a permanent means of arresting hæmorrhage—about twelve hours is a sufficient time to ensure the closure of the vessel. *A graduated compress should, therefore, not be kept firmly applied for more than twelve hours;* at the end of that time the bandages should be loosened without disturbing the compress, which will be sticking to the part, while the patient is kept very quiet with the limb raised. The inflammation or sloughing produced by excessive and prolonged pressure is the cause of the frequency with which arrest of bleeding by pressure is followed by secondary hæmorrhage.

In employing pressure, it must be borne in mind also that, *if applied accurately to the mouth of the bleeding vessel, the actual force required to stop the flow of blood is very small.* In the palmar arch, for instance, less than a quarter of an ounce accurately applied would close the mouth of the artery.

6. Forcible Flexion, as a means of arresting hæmorrhage from the

arteries of the limbs, has in recent years been advocated by Heath of Newcastle, Adelmann of Dorpat, and others. Its application is founded on the fact, specially pointed out in 1843 by Formey, that flexion of the arm at the elbow-joint weakens or arrests the pulsation at the wrist. Malgaigne, Vidal, Fleury, Fry, and some other Surgeons, have reported cases in which the plan was employed successfully; but until lately the method has attracted little attention. Heath, from a number of experiments made by him in the Newcastle Infirmary, has found that flexion of the arm at the elbow, or of the leg at the knee, diminishes or arrests the pulse in the distant arteries. In this respect he confirms the observations of Hyrtl and others; but he finds also that in the arm the process is greatly aided by placing a piece of lint or a handkerchief rolled up in the bend of the elbow; and in the lower limb, by bending the thigh on the abdomen at the same time that the leg is bent at the knee. Where flexion acts successfully as a means of hæmostasis, as it is reported to have done in several cases—especially in wounds of the palmar arteries and the vessels of the fore-arm—it probably does so by weakening the current of blood, so as to favour the closure of the arterial wound in the

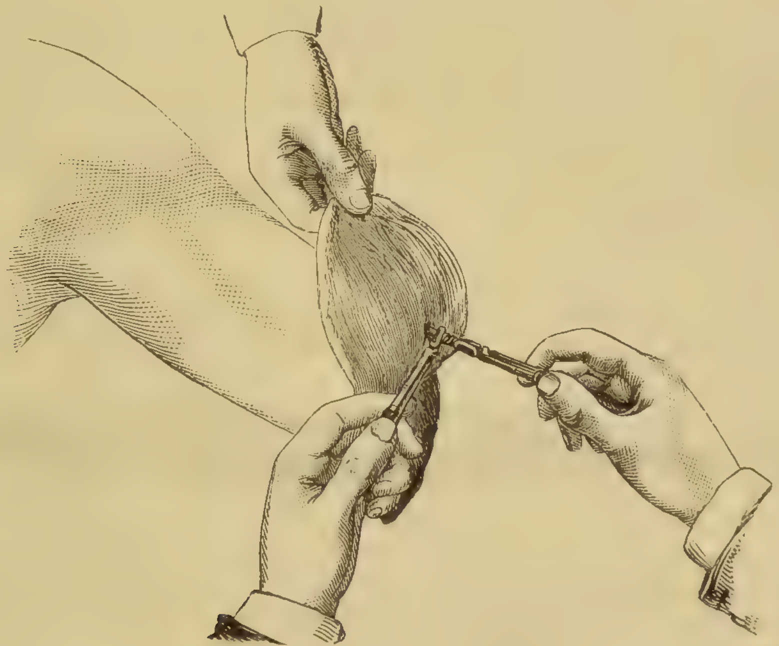


Fig. 138.—Torsion of Brachial Artery.

manner described in speaking of the Natural Arrest of Hæmorrhage. The apparent simplicity and safety (when carefully applied) of flexion render it worthy of further trial in cases of injury of the arteries of the fore-arm and hand or of the leg and foot. A roll of lint or other soft material having been placed in the flexure of the joint, the limb should be bent until it is perceived that the hæmorrhage is arrested, and should then be maintained in position by means of a handkerchief or bandage. Care must of course be taken not to exercise too great compression, by which gangrene might be produced. The flexion should be kept up till the Surgeon, by careful examination, is satisfied that there is no further risk of hæmorrhage.

7. Torsion of Cut Arteries for the arrest of hæmorrhage is mentioned

by Galen; but the practice seems to have been forgotten until about 1828. It was revived in France by Amussat, Velpeau, and Thierry; and in Germany by Fricke, who experimented upon and practised this method of treating divided arteries, with much ingenuity and perseverance. But, notwithstanding the efforts made to force it on the attention of Surgeons, it was gradually abandoned, even by its strongest advocates. Torsion has never come into general use amongst Surgeons in this country, and has, certainly, been too much neglected. It may be practised in various ways. Thus, Amussat recommended that the artery be drawn out for about half an inch by one pair of forceps; that it then be seized close to the tissues with another forceps, and that the end be twisted off by about a dozen turns (Fig. 138). This plan is applicable only to the larger arteries which can be cleanly isolated from the surrounding parts. Velpeau and Fricke advised that the end be not taken off, but merely twisted seven to eight times, according to the size of the vessel. Thierry simply seized the artery and twisted it in the direction of its axis. In seizing the artery it is particularly important, as Dupuytren has pointed out, that the whole vessel be grasped by the forceps, and that care be taken not to introduce one blade into the open end of the vessel, and thus twist only half of it. There can be no doubt that hæmorrhage from the largest vessels may be effectually stopped by torsion. Amussat and Velpeau repeatedly used it to close the femoral, brachial, ulnar, and radial arteries in amputations of the thigh, arm, and forearm; and more recently Cooper Forster and Bryant, at Guy's Hospital, and Callender at Bartholomew's, have used it successfully as the only means of arresting arterial hæmorrhage after operations; and their experience shows that, to say the least, it is as safe as any other mode of occluding a wounded artery.

In order to apply torsion successfully, a strong pair of forceps, with accurately-fitting serratures, must be used (Fig. 139), and the width of the

Fig. 139.—Torsion Forceps.

blades should vary with the size of the artery to be twisted. In applying torsion to a large vessel, it is better not to twist the end completely off; three or four sharp turns usually suffice, during which the inner and middle coats are felt to give way, and all resistance to cease. Smaller vessels may be twisted till the part included in the forceps comes off. Even with small vessels it will be found that the more cleanly the vessel can be isolated the more certainly will the bleeding be stopped. Torsion is most easily applied to large vessels, which can be cleanly seized in the forceps; it is most difficult with small vessels, especially if they are situated in dense structures, or in tissues infiltrated with inflammatory products. Bryant states that degeneration of the inner and middle coats in no way increases the difficulty in securing the artery, fewer turns in fact being required to close a diseased than a healthy vessel.

In torsion an artery is placed in the condition of one that is lacerated or torn through. The inner and middle coats are ruptured immediately above the part seized in the forceps, and are turned upwards into the lumen

of the vessel; the external coat is twisted into a kind of screw beyond them (Fig. 140). If a large vessel be treated in this way in the dead body and cut off about half an inch above the twisted part, it can be seen by looking down the lumen of the vessel that the inverted inner and middle coats completely close the vessel in a manner roughly resembling the closed aortic valves. A coagulum forms, adherent at its lower end to the injured coats, and the subsequent changes within the vessel are identical with those already described (p. 397) as occurring in permanent occlusion of a divided artery. The twisted end either becomes absorbed after being embedded in the coagulable exudation that unites the surface of the wound in the first few hours, or it separates as a slough if exposed to unfavourable conditions, as in an ill-drained wound with decomposing discharges, or on an open surface.

Fig. 140.—A Femoral Artery from a fresh dead body, twisted freely and laid open. The inner and middle coats are turned up into the lumen of the vessel for half-an-inch.

Torsion and Ligature Compared.—The employment of torsion as a substitute for the ligature is advocated on three grounds: 1, that, whilst equally safe, it is more easy of application; 2, that it is less liable to be followed by secondary hæmorrhage; and 3, that when an artery is closed by torsion, no foreign body is left in the wound that could interfere with its direct union.

Let us briefly examine the advantages claimed for torsion over the ligature.

1. So far as ease of application is concerned, there can be no doubt that the advantage is in favour of the ligature. This is very markedly the case with small vessels and those that cannot be drawn out of the sheath. In the case of the larger arteries, that can be denuded and drawn out of the neighbouring tissues, it is at least as easy to throw a thread round the exposed vessel as to twist it up securely.

2. With reference to the comparative freedom from secondary hæmorrhage, we have few data; but all those Surgeons who have extensively employed torsion agree in stating that it is very rarely followed by secondary hæmorrhage. The same may, however, be said with equal truth of the catgut and other absorbable ligatures which are almost universally used at the present time.

3. The torsion of arteries was strongly advocated on the ground that, whilst quite as safe as the ligature, there would after its employment be less liability to inflammation and suppuration, as no foreign body was left in the wound. This argument was used especially by Amussat; Manec and others maintained that the twisted end, of a large artery at any rate, is in reality a foreign body. In the present day, when the treatment of wounds is so much better understood than it was at their time, these arguments are of but little practical importance. We know that a piece of dead tissue, the size of the twisted end of an artery, becomes speedily buried in the plastic exudation that forms during the first twenty-four hours after the infliction of a wound, provided that the cavity is properly drained, and the surfaces brought accurately together and kept at rest; and that under these circumstances it is readily absorbed without causing inflammation or suppuration. In fact, it acts as an irritating foreign body only

when it remains uncovered and undergoes decomposition. The same is true of the absorbable ligatures in common use at the present day. On the other hand, the old silk ligature, the ends of which were left hanging out of the wound, infallibly acted as an irritant, and excited suppuration in its track. Torsion, therefore, undoubtedly presents advantages over the old silk ligature, and is equally safe and no more likely to interfere with primary union than an absorbable ligature. The latter possesses, however, the advantage of much greater ease of application, and is therefore preferred by the majority of Surgeons.

8. Forci-pressure is a mode of arresting hæmorrhage which has been recommended as of use in certain cases by Sir Spencer Wells, Kæberlé, and Péan. It consists in seizing the end of the vessel in a pair of forceps having strong short blades somewhat deeply serrated, and long scissor handles provided with a catch (Fig. 141). The forceps can be closed with sufficient force to crush the end of the vessel between their blades. The form of forceps represented in the figure is that invented by Sir Spencer Wells, which is certainly the most convenient and efficient. The use of these forceps as a temporary means of arresting hæmorrhage has been already alluded to. When used in this way it will frequently be found that, on relaxing their hold after a few minutes, no bleeding takes place. Under these circumstances, experience shows that the closure of the vessel is as safe as that effected by torsion. Should the Surgeon wish to make the arrest of bleeding still more certain, he may give the forceps a few turns while removing them, and thus apply torsion. Forci-pressure is occasionally useful in deep wounds in which a ligature cannot be applied. In these cases, in order to make the closure of the vessel more certain, the forceps may be left in the wound for twelve or twenty-four hours and then carefully removed.

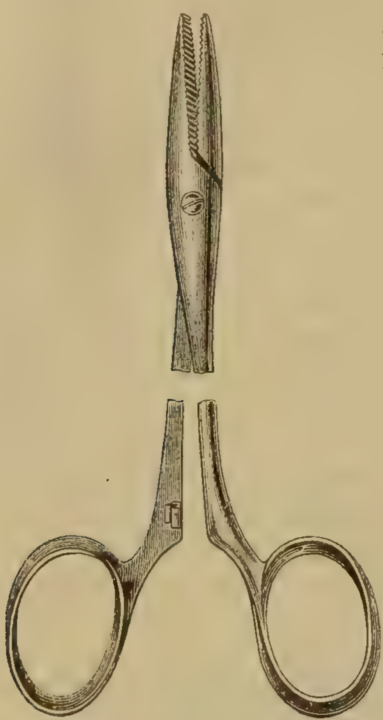


Fig. 141.—Forci-pressure Forceps.

9. Ligature is the means to which Surgeons commonly have recourse for the arrest of hæmorrhage from wounded arteries.

The Ligature had been occasionally and partially employed by the later Roman Surgeons; but with the decline of Surgery during the dark ages it fell completely into disuse, giving way to such barbarous and inefficient modes of arresting hæmorrhage as the employment of the actual cautery, the performance of operations with red-hot knives, or the application of boiling pitch, or of molten lead, to the bleeding and freshly cut surface. About the middle of the sixteenth century it was revived or re-invented by that great luminary of the French school of Surgery, Ambroise Paré. But so slowly did the ligature make way, that Sharpe, Surgeon to Guy's Hospital, writing in 1761, two centuries after its re-introduction by Paré, found it necessary, in his well-known work, entitled, "A Critical Enquiry into the Present State of Surgery," formally to advocate its employment for the arrest of hæmorrhage from

wounded arteries, in preference to styptics or the cautery, on the ground that "it was not as yet universally practised amongst Surgeons residing in the more distant counties of our kingdom." What, it may be asked, was the reason that it took two centuries to promulgate the use of the simplest and most efficacious means we possess in surgery for the arrest of hæmorrhage—a simple tying up of a spouting artery—a means that no Surgeon could now for a day dispense with? The reason simply was, that Surgeons were totally ignorant of the means employed by Nature for the occlusion of arteries; that they consequently did not know how to apply a ligature to these vessels, or what kind of ligature should be used; and that, in their anxiety to avoid the occurrence of secondary hæmorrhage, and to make all safe, they fell into the very errors they would have endeavoured to avoid, had they been acquainted with the physiology of the processes by which Nature accomplishes the closure of the artery and the separation of the thread.

Between twenty and thirty years after the time at which Sharpe wrote, Hunter introduced that great improvement in the surgical treatment of aneurism—the deligation of the artery at a distance from the sac, and in a healthy part of its course; but this great accession to the treatment of a most formidable disease was but coldly received, and ran some risk of being lost to the world in consequence of the ill-success that attended the earlier operations. In Hunter's first operation, four ligatures were used, each of which was applied so slackly as merely to compress the artery, in order to avoid too great a degree of pressure at any one point; and the artery was denuded, so that a spatula could be passed under it. Although in his subsequent operations Hunter contented himself with employing but one ligature, yet sometimes the vein was included in this; and he did not draw the noose tight for fear of injuring the coats of the vessel, in accordance with the doctrine of the day—Surgeons generally at this time being haunted by the dread of injuring, and thereby weakening, the coats of the artery; and, in order to avoid doing so, they adopted modes of treatment that almost infallibly led to ulceration of the vessels and consecutive hæmorrhage. The application of several ligatures of reserve, applied slack—the use of broad tapes—the interposition of plugs of cork, wood, agaric, or lead, or of rolls of lint or plaster, between the thread and the vessel, were some amongst the plans that were in common use. And how can we be surprised that the patients perished of hæmorrhage, and that ligature of the vessel was nearly as inefficient and fatal a means of arresting bleeding as the use of a cautery, or of a button of white vitriol?

Jones, by an appeal to experiment, and by means of a series of admirably conducted investigations on living animals, showed that the very point which Surgeons were anxious to avoid—the division of the coats of the vessel by the tightening of the noose—was that on which the patient's safety depended; he also pointed out the form and size of ligature that was most safe, the degree of force with which it should be applied, and the processes adopted by Nature for the occlusion of the vessel. Thus a more rational practice was introduced, and then, for the first time, Surgeons had full confidence in the use of the ligature.

Application of the Ligature.—The mode of application of the ligature varies according as, 1, the cut end of the artery has to be tied in an open wound, or as, 2, the vessel has to be secured in its continuity.

1. When the **divided vessel in an open wound** has to be tied, as after an

amputation, the mouth of the artery must be seized and drawn forwards (Fig. 142). For this purpose a tenaculum, or sharp hook, was formerly used, and answered the purpose very well. There are, however, some objections to this instrument; thus, it occasionally seizes other tissues with the artery, and, as it draws the vessel forwards by perforating its coats, it has happened that, an accidental puncture having been made by it behind the part to which the ligature is applied, ulceration of the vessel and subsequent fatal hæmorrhage

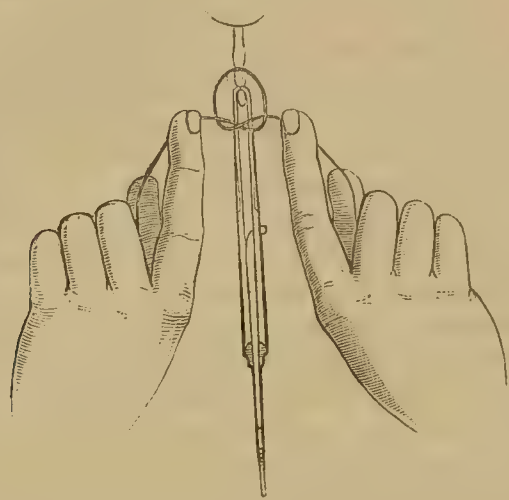


Fig. 142.—End of Artery drawn forwards. Application of Ligature.

have ensued, as I have seen in one case. The most convenient instrument for the purpose of drawing forward the artery, and one to which no objection

Fig. 143.—Liston's "Bull-dog" Forceps, modified.

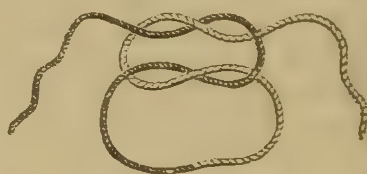


Fig. 144.—The Ligature-knot.

whatever applies, is Liston's "bull-dog" forceps. These have been conveniently modified by having the blades expanded just above the points (Fig. 143), so that the ligature can be slipped over their end on to an artery that is deeply seated, as between bones or close to the interosseous membrane of the leg—a situation in which it is sometimes troublesome to tie a vessel by any other means.

In applying the ligature, care must be taken that it be put well over the cut end of the artery, that it clear the points of the forceps, and that it be tied tightly in a knot, which does not slip (Fig. 144). As the knot is tightened, the tips of the forefingers should be in close contact with the points of the forceps, and be pressed slightly downwards on the artery, otherwise the vessel may be dragged forwards out of its bed, or the forceps pulled off it. In some cases the bleeding point may be so situated, that the ligature is most conveniently passed under and round it by means of an ordinary curved needle.

After the ligature is tied, the ends must be cut off or left according to the nature of the material employed.

2. When the artery has to be ligatured **in its continuity** at the injured spot for a wound which does not completely divide it, it must be exposed by as careful a dissection as the state of the parts will admit; the wound being enlarged, if necessary, in such a direction as to do the least possible injury to surrounding parts.

If for any reason a Surgeon determine to apply a ligature at a distance from the seat of the disease or injury, he selects that part of the vessel which is best adapted to the operation, and guided by his anatomical knowledge exposes it in the chosen spot. The definite operations by which each of the main arteries may be exposed and tied will be described in the Chapter on the treatment of Special Aneurisms; but the general principles which guide the Surgeon in the application of a ligature to a large artery in its continuity will be given here.

Whenever it is possible, the ligature should be applied at some distance from any branch, in order that the formation of the internal coagulum may not be interfered with, either by the stream of blood leaving the main trunk immediately on the proximal side of ligature, or entering it by means of the collateral circulation on the distal side. When this is impossible, it is safer to apply the ligature on the proximal side of the branch, so that a clot may be formed above it and protect the injured part of the vessel from the direct impulse of the stream of blood from the heart. In some cases, especially if the anastomosing vessels are very abundant, it would be safer to ligature the branch also close to the main trunk.

Other things being equal, that part of the artery is to be chosen which is most superficial, and in relation with the fewest important structures. Thus the point selected in the carotid is above the omo-hyoid, and the superficial femoral is always, when possible, tied in preference to the popliteal.

Having determined the point to which the ligature is to be applied, the operator first makes an incision through the skin and fat to the deep fascia; he then, by a process of careful dissection, exposes the sheath of the vessel, and finally opens the sheath and passes the aneurism needle between it and the external coat.

The first incision is usually made in the course of the vessel; for in most parts of the body the chief nerves, veins, and muscles, run in the same line as the main artery. When, however, an incision in the line of the artery would injure important parts, the Surgeon must make an oblique or transverse wound, the direction being determined by the anatomical relations of the part. Thus in ligature of the brachial at the bend of the elbow, the incision is made across the line of the artery, in order to avoid the median basilic vein; and in ligature of the external iliac it is made nearly parallel to Poupart's ligament to facilitate the retraction of the peritoneum in exposing the artery. In making the incision, the Surgeon is guided by some fixed line known as the "*directing or guiding line.*" In some cases this corresponds with the anatomical line of the artery, as in the operation for ligature of the anterior tibial; in others it is distinct from this, having reference rather to the structures which have to be turned on one side to expose the vessel. Thus in the operation for ligature of the carotid artery, the directing line for the first incision is the inner edge of the sterno-mastoid, while the line of the artery is from midway between the

angle of the jaw and the mastoid process to the sterno-clavicular articulation. Both the anatomical line of the artery and the surgical directing line should be carefully studied and kept in mind.

In making the first incision, the skin should be put on the stretch by the fingers of the left hand. The length of the incision will necessarily vary with the depth of the artery and with the amount of superficial fat ; but it must always be of sufficient length to give the operator a clear view of what he is doing in the deeper dissection. If the artery be superficial, or if there be parts of importance in its vicinity, the incision should not penetrate deeper than the skin. But if the vessel be deeply seated and no parts of importance intervene, it may be carried at once through the subcutaneous areolar tissue, until the fascia is exposed. This must then be pinched up with the forceps, and opened by the edge of the scalpel laid horizontally (Fig. 51, p. 39). Through this opening a grooved director may then be passed, and the fascia incised upon it, without risk to subjacent parts ; or the fascia may be carefully divided by the method described on p. 40, Fig. 6.

If the vessel be superficial, its sheath will come into view as soon as the deep fascia is divided, and the operator proceeds at once to clean the artery and to pass the ligature ; but if it be more deeply seated, the dissection must be continued till the vessel is exposed. In carrying out the deeper dissection, the Surgeon is still guided by definite anatomical points, each of which must be made out in order, and clearly recognized. Malgaigne gave these the name of the "*rallying points*" of the operation, and laid down the following excellent rule :—"The Surgeon should not at once set himself to look for the artery, but should seek solely the first rallying point ; then the second, then the third, if there is one ; and so on, till he reaches the vessel." Thus in the operation of ligature of the carotid, the first rallying point is the inner edge of the sternomastoid, and until that is made clear, nothing else should occupy the operator's mind ; the second point is the upper border of the anterior belly of the omo-hyoid, and it is not till this is found and drawn downwards that the artery itself need be thought of. During the deeper dissection required to expose the artery, the wound must be held open with blunt hooks or copper spatulæ, and this duty should if possible be entrusted to a single assistant. If two undertake it, one is sure to pull more strongly than the other, and thus disturb the relation of the superficial wound to the deeper parts.

Having reached the sheath, the next step of the operation consists in exposing the artery, and is one of great delicacy. The object of the operator is to open the sheath in such a way that the needle can be passed between it and the external coat, and at the same time to separate the artery from its sheath for as short a distance as possible. Separation of an artery from its sheath cuts off the blood-supply of its coats, as this is derived from the vasa vasorum which ramify in the sheath; if, therefore, the artery be separated extensively, the isolated part will slough, as happened when several tapes were used. At the same time, it is very important that the artery be really separated cleanly from the sheath, as if this is done a smaller amount of tissue is included in the ligature, and the division of the inner and middle coats is more perfectly effected. Perfect cleaning of the artery, moreover, greatly facilitates the passage of the needle. If we cut an artery through, it retracts, as we have before seen, within its sheath, leaving that attached to the surrounding parts. This clearly shows that the sheath is more adherent

to the surrounding parts than to the external coat, and that the loosest tissue, through which the needle will pass most readily, is that between the sheath and the outer coat. In fact, if the artery be properly cleaned, it is very unlikely that any accident will happen in passing the needle.

It must not be forgotten that some of the larger arteries are enclosed in a sheath derived from the fascia of the part, and it is important not to confound this with the true sheath. Thus, the carotid artery is enclosed in the sheath of cervical fascia common to it, the jugular vein, and the pneumogastric nerve, and in this case the operator will have to open the true sheath of the artery after having exposed it by opening the common sheath. The sheath of an artery may usually be recognized by the small vessels that can be seen ramifying in it, while the external coat is almost white, like the conjunctiva and the sclerotic of the eye respectively. Syme's rule in cleaning an artery, "to dissect down till the 'white coat of the vessel' comes into view," is founded upon this fact.

The sheath is opened by pinching it up with the forceps and applying the knife horizontally (Fig. 145). The point should never be used,

Fig. 145.—Opening the Sheath.

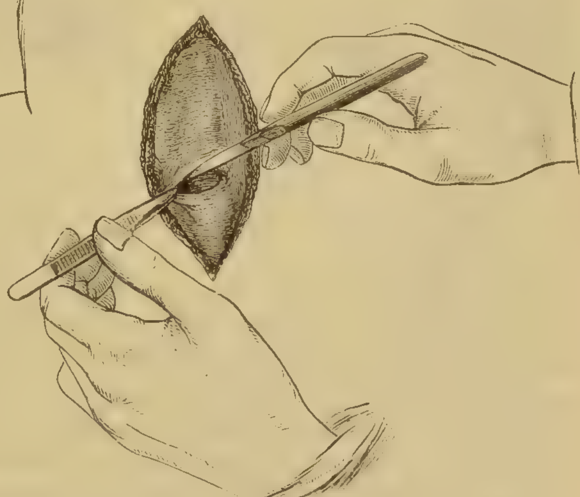


Fig. 146.—Cleaning the Artery.

nor the blade turned downwards against the artery, as an incautious movement or the mere pulsation of the vessel might cause it to be wounded. If the white coat of the artery does not come into view at once, it will be because the sheath is not completely divided, and the operator must then pinch it up again in exactly the same place, and again cut the areolar tissue seized in the forceps. The appearance of the white external coat, and the exceedingly loose areolar tissue which comes into view, show him when he has completely opened the sheath. He then catches hold of the edge of the opening he has made and, putting it on the stretch, proceeds to clean the artery, gently separating it from its sheath by teazing through the loose areolar connections with the point of the knife, the back turning to the artery (Fig. 146), and being careful not to expose more than is necessary, but at the same time to clean thoroughly the part to be tied. Some Surgeons, after opening the sheath, prefer to clean the

artery with the point of a director, and there is no doubt that if the instrument be carefully used it can be made to do the work efficiently; but it is more difficult to clean the artery thoroughly with it than with the knife. During the process of cleaning, the artery itself must on no account be seized in the forceps, and care must be taken not to wound any small branch. Should this happen, the artery must be tied on each side of the injured spot.

The artery being thoroughly clean, the ligature may now be passed. Much ingenuity has been expended in devising instruments for this purpose; in the majority of cases the common aneurism-needle—well ground down, but rounded at its extremity—is all that is required; but occasionally it may be advantageous to use a needle with a small curve. To pass the

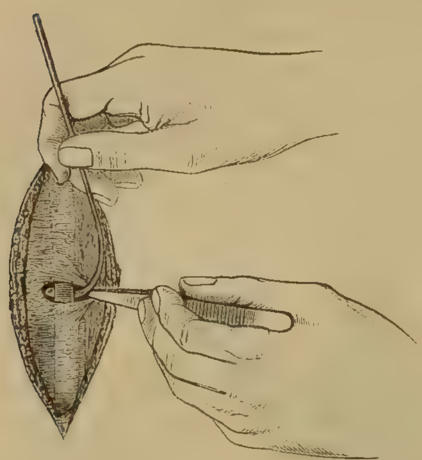


Fig. 147.—Passing the Needle: 1st stage.

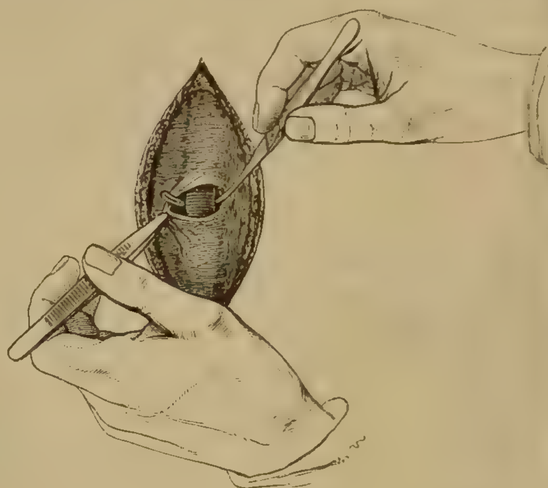


Fig. 148.—Passing the Needle: 2nd stage.

ligature, the edge of the opening in the sheath must be held tightly in the forceps and pulled slightly so as to put it on the stretch. The needle is then passed from the forceps (Fig. 147); as soon as its point begins to appear on the other side of the artery the operator must shift the forceps to that side, and catching hold of the edge of the opening in the sheath must draw it out of the way of the point of the needle (Fig. 148). The needle should be passed without the ligature, and afterwards threaded whenever this is possible. In very deep-seated arteries, such as the iliacs, this is often impracticable; it must then be passed threaded, and the loop of the ligature caught in a pair of forceps before the needle is withdrawn.

The needle must always be passed *from the most important structures* in the neighbourhood; thus, when a single large vein accompanies the artery, it must be passed from this; when there is a vein on each side and a nerve on one side, it must be passed from the nerve. If care be not taken, the vein may be transfixed or included in the ligature; an accident that has often terminated fatally by phlebitis or gangrene. The Surgeon must be on his guard not to mistake any contiguous nerve for the artery, as has happened to the most experienced operators; and also to avoid transfixing and tying a portion of the sheath instead of the vessel, as I have known happen to a most excellent Surgeon. These accidents can scarcely occur in a healthy state of the parts if the artery be thoroughly and carefully cleaned, and the needle passed actually in contact with the external coat.

After the ligature has been passed, its two ends should be held firmly in one hand and the fore-finger of the other hand pressed down into the loop, while an assistant feels the pulsation of some branch below, or of the tumour in the case of an aneurism. If the pulsation is arrested by the pressure of the finger in the loop of the ligature, the operator is sure that he has got the artery, and he may tie the knot. The ends of the ligature are then cut off close or left hanging out of the wound, according to the material of which it is composed.

In ligaturing an artery in its continuity the injured portion is necessarily exposed to the longitudinal strain due to the elasticity of the artery. On the other hand, when the vessel is completely divided and each end tied separately this source of disturbance is removed. It has been frequently suggested that it would be safer in all cases to apply two ligatures and to divide the artery between them. This practice has had many advocates, the chief of whom in this country was Abernethy ; but it never came into general use. It has, however, lately been revived by Walsham in St. Bartholomew's hospital, and possibly it may be of service in those parts of the body in which it is not easy by position to relax the vessel and keep it at perfect rest after it is tied.

Effects of Ligature.—The immediate effects on an artery of the application of a silk or thread ligature with a proper degree of force are the division

Fig. 149.—Immediate effects of the Application of a Ligature.

Fig. 150.—Femoral Artery, fifty-six hours after Amputation.

of the internal and middle coats of the vessel (Fig. 149), and the constriction of its outer one. The divided coats are separated for a short distance from the external coat and turned upwards and downwards into the lumen of the vessel.

The first change that takes place after the application of the ligature is the **Formation of the Internal Coagulum,** which is an important part of the process of permanent obliteration of the artery. For the first few hours there is little if any appearance of this ; but, if opportunity offer to examine an artery in the human subject about twenty-four or thirty-six hours after the application of the ligature, a coagulum will usually be found extending some distance from the ligature and adherent by its base to the injured part of the vessel. The part in immediate contact with the divided inner and middle coats will by this time be found to be of a yellowish or buff colour, owing to its being infiltrated or replaced by the inflammatory exudation which has been poured out in the bottom of the *cul-de-sac* formed by the turning inwards of the divided coats. About the third day the clot (Fig. 150) will be found to be conical in form, firmer in structure, and more adherent to the inner coat of the artery,

and by this time it extends most frequently as far as the nearest branch given off from the vessel above the ligature. Its base is more distinctly decolourized,

Fig. 151.—Ligatured Artery laid open, showing internal coagulum.

Fig. 152. — Partial Absorption of Coagulum in Femoral, fourteen days after Amputation.

the remainder being of a dark purple or maroon colour. Its apex lies loose and floating in the artery.

The further changes that occur within the artery are the same as those

Fig. 153.—Femoral Arteries, ten days after Amputation of Thigh. Death from Pyæmia.

Fig. 154.—Femoral Artery, six weeks after Amputation.

already described as taking place in the permanent closure of a divided artery (page 297).

In some cases there is an imperfect formation of the internal coagulum, or even a total absence of it should a branch arise immediately above the ligature. In other cases the insufficient formation of the coagulum is apparently due to the constitutional condition of the patient. Sometimes the clot seems to undergo a kind of disintegration or liquefaction after it has been formed. This I have seen happen in a case of ligature of the carotid artery, in which death occurred from visceral disease ten weeks after the operation; and in the femoral, in cases of pyæmia (Fig. 152).

When an artery is ligatured in its continuity, the coagulum formed in the distal *cul-de-sac* is seldom as abundant as that on the proximal side of the ligature. In other respects the internal changes that occur are identical on the two sides of the ligature.

The **changes that take place outside the artery** are of equal, if not of greater, importance than those going on within. They require, however, no special description, for they are merely the ordinary processes of repair, such as go on in the union of a wound. As an immediate consequence of the injury necessitating the application of the ligature, or inflicted in applying it, an abundant coagulable exudation takes place, and before twenty-four hours are past the space between the external coat and the sheath for some distance on each side of the ligature is filled by firm "coagulable lymph," composed of migrated white corpuscles entangled in the meshes of coagulated fibrin. The ligature itself, the injured part of the artery, and, in the case of a divided vessel, the part beyond the ligature, are speedily embedded in the same material. The subsequent processes depend entirely on the nature of the material of which the ligature is composed, and the success attending the Surgeon's efforts to obtain primary union of the wound. *If the ligature itself is unirritating,* and the conditions necessary for primary union of the wound (see page 269) are present, vascularization of the exudation commences on the second day, and the injured part of the vessel is, before many days are past, surrounded by firm granulation-tissue developing into the fibrous tissue of the scar. The ligature, as we shall see hereafter, if absorbable, becomes penetrated by leucocytes and disappears, this process being unaccompanied by acute inflammation or suppuration; and the experiments of Tillmanns and others have shown that the same process takes place in the portion of the artery beyond the ligature. The similar changes which are taking place in the nodule of exudation-matter within the vessel can, under these circumstances, proceed without any disturbance from without. Under such favourable conditions as these, secondary hæmorrhage is impossible, and thus it is that statistics show that the modern improvements in the treatment of wounds have diminished the frequency of secondary hæmorrhage in the same proportion as they have diminished pyæmia and other unhealthy processes. But *should the ligature be composed of an irritating material* which has to cut its way through the ligatured vessel by ulceration, a localized inflammation with suppuration is kept up in the immediate neighbourhood of the injured part of the artery. As a rule this process is closely limited to the immediate neighbourhood of the ligature; and, by the time the noose ulcerates through the external coat, repair is sufficiently advanced within the vessel to render it capable of withstanding the force of the blood-stream—the firm adhesion of the clot to the inner coat serving under these circumstances the important purpose of breaking the direct impulse of the wave of blood upon

the new tissue closing the vessel. There are two sources of danger in connection with the coming away of the ligature; either the sloughing may be too extensive, or the ulceration through the artery may take place before the reparative material within is sufficiently firm. Too extensive sloughing may arise when the artery is tied in its continuity, from the vessel having been separated from its sheath to too great an extent during the dissection required to expose it, and its nutrient vessels being consequently divided in great numbers, so as to deprive that portion of the coats of the vessel of its vascular supply; hence the danger of passing a spatula, director, or the handle of a scalpel under the artery, and also of applying several ligatures or a single wide ligature. When the artery has been divided, sloughing is most commonly the result of unhealthy septic processes going on in the wound, especially if the artery have been cut long, so that its free end is bathed in the decomposing discharges. Premature ulceration of the vessel may occur from the use of too thick a ligature, which, as before stated, by causing greater irritation, hastens the process of separation; from excessive degeneration or inflammatory softening of the artery at the point ligatured; or from unhealthy processes occurring in the wound, especially the presence of pent-up decomposing discharges.

So soon as the ligature has ulcerated through that portion of the artery which is included in its noose, it becomes loosened and separates; frequently being thrown off with the discharges, or becoming detached on the slightest traction. The period of the separation of the ligature depends upon the size of the artery, the thickness of its coats, and of the ligature itself. From the radial or ulnar arteries, it is usually detached by the eighth day; from the femoral, iliac, or subclavian, about the sixteenth or twentieth day. In some cases the ligature will continue attached for a much longer period than this, owing to the inclusion within its noose of a bit of fascia, nerve, or muscular substance. In order to hasten the separation in these cases, moderate traction and occasional twisting of the ligature may be practised.

The Ligature.—The best material to use for tying an artery has been the subject of much experimental inquiry and abundant discussion, and can hardly yet be said to be finally determined. Ligatures may be divided into two chief classes: first, those intended to cut through the artery by a gradual process of ulceration, and then to be removed from the wound; and secondly, those intended to become enclosed in the wound during the process of healing, and either to remain permanently encapsuled or to be absorbed.

1. Until about fifteen years ago, when absorbable ligatures were re-introduced into practice in connection with the antiseptic treatment of wounds, the vast majority of Surgeons made *use of ligatures which were removed from the wound after having cut through the artery by a process of ulceration.* The material commonly employed with this object is, either "dentist's silk" or compressed whip-cord well waxed. The ligature is waxed for three reasons: first, to make it more easy to tie when the operator's hands are slippery with blood; secondly, to prevent the danger of the knot slipping after it has been tied; and thirdly, to render it as far as possible non-absorbent, and thus to prevent its taking up septic matter, and becoming needlessly irritating. In the absence of special antiseptic precautions, however, this last object is but

imperfectly attained. The ligature always becomes impregnated with the products of putrefaction, and thus acting like a seton produces a suppurating track in its course. Inflammation and suppuration are thus kept up at the part of the vessel to which the ligature is applied until it separates, and the source of irritation is thus removed. Thus no true repair can take place outside the ligatured vessel till after the removal of the ligature. In the vast majority of cases, however, the processes of repair going on inside the vessel are quite sufficient to close the artery safely; and thus hæmorrhage on the separation of the ligature is of comparatively rare occurrence. As has already been stated, the period at which the process of ulceration through the external coat is completed varies with the size of the artery and the thickness of the ligature. Malgaigne pointed out that the size of the ligature also exercises a marked influence on the time at which it comes away; the thicker the ligature the more irritation it excites, and the sooner is the process of ulceration through the vessel completed. It is therefore safer to use the finest thread possible, provided it is of sufficient strength, as thereby the danger of premature separation is to a great extent avoided, while at the same time the inner and middle coats are more cleanly divided. In some rare cases, as, for example, when the coats of the artery are softened by inflammation, it may be necessary to use a thicker ligature for fear of cutting through the external coat; but with healthy vessels the larger arteries require no thicker ligatures than the smaller. If it be intended to remove the ligature, one end may be cut short and the other brought out of the wound at the most convenient part. The ligature on the main artery in an amputation may have both ends left, and knotted together as a distinguishing mark. After the first four days the ligatures on the smaller vessels may be gently pulled to see if they are loose, but no force should be used. The ligature on the main artery should not be touched till after the tenth day in the arm, and the fourteenth in the lower limb.

Ligatures are much less frequently applied in this way at the present time than they were formerly, except on open surfaces in which healing must take place by granulation.

2. *Ligatures which become enclosed in the wound during the process of healing, and remain permanently encapsuled or become absorbed.*

Wire Ligatures have been used with this intention in America. The idea originated with Physick and Levert of Alabama, who performed several experiments with threads of gold, silver, platinum, and lead. They found that with these the arteries of animals could be successfully tied, and that, the material of the ligature being unirritating, no evil from suppuration ensued. When the ends of the ligature were cut off close to the vessel, it was found that the small metallic noose became embedded in a cellular capsule. For some reason this means fell into disuse, until it was revived by Marion Sims. At his suggestion I tried it in several cases of amputation and other surgical operations, but soon abandoned it, as I found great inconveniences resulting from its use. If the ends of the wire were left out of the wound, the noose became embedded in a mass of plastic matter, did not separate, and, after several weeks, required considerable force to detach and disconnect it. If the ends were cut short, the sides of the wound healed over them; they became encapsuled, but were by no means innocuous; in some cases giving rise to severe neuralgia of the stump by pressure on and irritation of neighbouring

nerves; in others, after some weeks, causing localized circumscribed abscesses to form.

The employment of **Ligatures made of Materials that admit of Absorption** in the wound was long ago a favourite idea with many Surgeons, and is one on which much experimental ingenuity has at various times been expended: for the idea is a captivating one, and if it can be safely, certainly, and successfully carried out in practice, it will undoubtedly remove one of the obstacles to the union of wounds by the first intention. With this view, it was proposed to substitute ligatures made of animal substances for the ordinary threads made of hemp. Silk thread cut short and left in the wound was used by Sir W. Lawrence in 1815, and at first with success, union of the wound taking place in four to six days, without suppuration. But other Surgeons failed in this, and Lawrence himself was soon compelled to give it up from want of good results in his subsequent cases. Wardrop substituted the gut of the silk-worm made into a fine cord, but with equally unsatisfactory results.

Catgut was used by Sir Astley Cooper as a material that was more likely to dissolve, or to be absorbed, than silk in any shape. The first cases in which it was employed as a ligature were full of promise. In one, a patient aged eighty, the wound healed in four days, and in another in twenty, and in neither did the noose of the ligature re-appear. But other Surgeons failed to imitate this success; the catgut was found to be too weak, and the distinguished author of the practice could not himself maintain his first success with it, and eventually fell back on the ordinary hempen thread.

Strips of deer-skin were used by Jameson, of Philadelphia, and other American Surgeons about the same time; probably in 1814, before Lawrence's or Cooper's experiments. They were found to answer better than either silk or catgut, being stronger, more elastic, and more readily soluble. These, however, also fell into disuse, for what reason does not clearly appear.

The idea of employing ligatures made of animal substances, that would admit of absorption, and allow the wound to be immediately closed over the noose—which would not, in fact, act as foreign bodies in the wound or as causes of suppuration—still occasionally presented itself to the minds of Surgeons; and, amongst others, Velpeau speaks of it with favour, admitting, however, that their precise nature and form have to be determined.

Carbolized Catgut.—Of late the use of catgut has been revived by Lister, in connection with his "Antiseptic Method" of dressing wounds, and experience has shown that, when properly prepared, it is a perfectly reliable material.

Unprepared catgut, such as was used by Sir Astley Cooper, is quite untrustworthy. In warm blood-serum out of the body it softens and becomes pulpy and useless in about half an hour. The original mode of preparation of the carbolized gut, as described by Lister, is as follows:—"It must be suspended for some weeks in an emulsion of water, carbolic acid and oil, in which, after growing soft and opaque during the first few days, it gradually experiences an opposite change, and at length becomes again quite transparent, and is then little affected by water, and holds better when tied than waxed silk. The emulsion is best made by mixing one part of crystallized carbolic acid, deliquesced by means of water, with five parts of olive-oil. The very fine emulsion that results is placed in a covered jar, having a partition of glass or other material

supported by pebbles at a short distance above the bottom, to afford space for water that slowly subsides to accumulate in and keep it from coming into contact with the hanks of gut which are placed loosely in the upper part of the vessel. The process of preparation goes on best in a cool place, and should be continued *for two months at least;* and the gut goes on improving for an unlimited time if retained in the same oil."

Excellent results were obtained from the gut prepared in this way, but the length of time required before it was fit for use formed a serious objection to the process. Lister therefore undertook a series of experiments with various re-agents in the hope of finding some equally efficient and more rapid method. Among the substances with which he experimented, chromic acid was found to give the best results; but if this is used alone or too strong, the gut becomes over-prepared and as unabsorbable as a wire ligature. The method of preparation finally adopted is the following. Dissolve one part of chromic acid in 4,000 parts of distilled water, and add to the solution 200 parts of pure carbolic acid or absolute phenol. Place in the solution a quantity of catgut equal in weight to the carbolic acid; the gut must not be in loose hanks, but wound round some solid body to prevent its untwisting while soaking. If too much gut be added, it will be under-prepared and soften in the wound; if too little, there is a danger of its becoming over-prepared and unabsorbable. At the end of forty-eight hours the preparation is complete, and the gut may be removed and dried. As soon as it is dry, it is to be placed in a 1 to 5 solution of carbolic acid in oil, and it is then fit for use; or it may be kept dry and put in a 1 in 20 watery solution for a quarter of an hour before it is used.

The fate of a prepared catgut ligature in a wound has been the subject of much discussion. The examination of ligatures applied in animals, and of pieces of gut used as sutures and ligatures in the human subject, have, however, tolerably clearly proved that, provided all goes well, the following changes occur. Within a short time of its application the carbolic acid it contains diffuses out of it into the surrounding serum, and the catgut then becomes a perfectly unirritating thread of fibrous tissue, and consequently has no tendency to excite inflammation or suppuration in its neighbourhood. It may, however, become irritating if, after losing its carbolic acid, it decomposes or becomes soaked in decomposing discharges. In this state it presents no advantage over an ordinary silk or hemp ligature; in fact, it is less safe, as by its premature softening it may leave the external coat unsupported before repair has sufficiently advanced internally. If preserved from decomposition by the antiseptic treatment, it becomes buried and absorbed in the granulation-tissue developed in the process of repair of the wound. In properly prepared catgut the absorption proceeds solely from the surface, the ligature swelling and softening but little. If such a ligature be examined when partially absorbed, it will be found that the surface has lost its smooth outline, being eaten out into hollows, which are filled with cells having the appearance of leucocytes. Occasionally a few larger, many-nucleated cells are met with. In an imperfectly prepared ligature the cells can be seen penetrating deeply into the substance of the gut between the bundles of fibrous tissue. Fig. 155 represents the surface of a piece of carbolized catgut $\frac{1}{25}$-in. in thickness, used as a deep stitch in a wound, treated antiseptically, which healed by the first intention. It was removed at the end of six days, and was still tough and strong, being

only superficially destroyed, about one-fifteenth of its thickness having disappeared. The gut was prepared by the old process, without chromic acid, and had been in carbolic oil for about three years. A portion of the same hank had been successfully used to ligature the femoral artery in a case of popliteal aneurism.

Finally, as has been shown by Lister, the ligature completely disappears, a little ring of new fibrous tissue being developed round the vessel in its place. Thus the artery is not cut through, the continuity of the external coat remaining uninterrupted. The inner and middle coats are as a rule cut through in the application of the ligature; but should it be thought advisable not to do this, as in the case of some of the larger arteries, it can be avoided by using the thickest obtainable gut, and employing less force in its application.

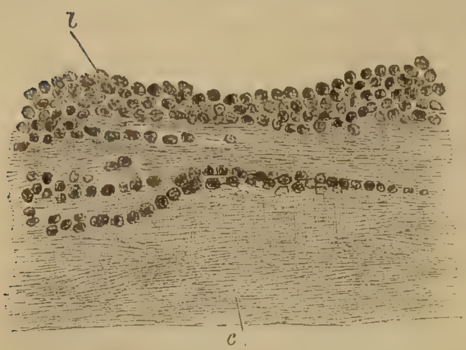


Fig. 155.—Absorption of catgut ligature, six days in an aseptic wound. Surface of catgut is splitting up. Leucocytes cover it and wander into the fissures. *l.* leucocytes; *c.* catgut fibres.

The use of the catgut-ligature has not however been limited to wounds treated antiseptically, and good results have been obtained in cases treated by other methods. In these cases the fate of the ligature is less certain. If it becomes buried in the coagulable exudation which in the first few hours unites the surfaces of a well-drained and -rested wound, it is protected from decomposition, and then follows the course above described. If it should become bathed in septic discharges it softens rapidly, and the knot is usually thrown off like a small slough; or the ligature may break up and disappear altogether.

The changes that occur within the artery after the application of a catgut-ligature do not differ, so far as is known, from those following any other mode of arresting arterial hæmorrhage.

The use of the catgut-ligature, although at least as successful as any other mode of arresting arterial hæmorrhage, has not been altogether unattended by accidents. These have been due in most cases to *premature softening* of the gut, or to *slipping of the knot*. The premature softening is caused by imperfect preparation. The older method of preparing carbolized catgut occupied at least two months, and even then it was occasionally underprepared. There seems reason to hope that this accident will for the future be avoided by the employment of the new form of catgut prepared by means of chromic acid. The slipping of the knot is sometimes due to the gut being too rigid to tie closely; such gut should never be used. Well-prepared gut will tie as closely as silk of the same thickness. When applied to an artery in its continuity, the catgut-ligature has in some cases failed to obliterate the vessel. Thus, in a case under the care of Christopher Heath, at University College Hospital, the femoral became pervious shortly after the operation, necessitating the application of a second ligature at a lower point. In a case recorded by T. Smith, of Bartholomew's Hospital, not only did the ligature fail to obliterate the artery, but a traumatic aneurism formed at the point at which it had been applied. McCarthy has also recorded a case in which the artery became pervious shortly after the operation. In these cases the

ligature failed to accomplish the purpose for which it was applied. It is most probable that in all it was due to premature softening of the gut. Treves also has recorded a case in which after 108 days the carotid artery was found to be patent but narrowed at the seat of ligature by a kind of perforated diaphragm. In a case at University College Hospital, in which the right carotid was tied below the omo-hyoid for an aneurism opposite the larynx, the vessel, when the man died of an aortic aneurism one year after, was then found to be obliterated from the aneurism to the innominate. Its coats were continuous, the seat of ligature being recognizable only by some cicatricial tissue adherent to the external coat. It seems possible, therefore, that as the continuity of the external coat is not destroyed, restoration of the lumen of the vessel may take place occasionally even after occlusion lasting a considerable time. In the vast majority of cases, however, in which the catgut-ligature has been employed, the vessel has been permanently and safely obliterated.

Carbolized Silk.—The slight degree of uncertainty that has attended the use of catgut, the occasional premature disappearance of the ligature and restoration of the circulation through the vessel, has led some Surgeons to employ instead of it fine silk, that known as "Chinese twist" being the best. Silk being an animal substance, and from its softness being unlikely to irritate mechanically, there seems no reason why, if it can be prevented from becoming impregnated with the irritating products of putrefaction, it should not lie harmlessly amongst the tissues, and become finally absorbed or encapsuled. That such may be the case has been abundantly proved by the experience derived from those cases of ovariotomy in which the pedicle has been secured by silk, and returned into the cavity of the abdomen. In order that silk may be used with safety and certainty, it must in the first place be rendered aseptic. This is most efficiently done by boiling it for some time in water, and afterwards placing it for twenty-four hours in a 1 in 20 solution of carbolic acid. It must on no account be waxed, as this makes it incapable of being absorbed. A silk ligature thus prepared will in the great majority of cases give rise to no irritation or suppuration in its neighbourhood. If, however, it should from any cause become exposed to decomposing matter, it will absorb the products of putrefaction, and will then be cast off and discharged from the wound by suppuration.

The fate of a silk ligature when left amongst the living tissues has been experimentally investigated by Lister, Spiegelberg and Waldeyer, Tillmanns, and others. Lister found an aseptic silk ligature applied to the carotid of a horse unchanged at the end of six weeks and embedded in firm fibrous tissue. In a case in which he applied a similar ligature to the external iliac artery in the human subject, when he had the opportunity of examining the parts one year after, he found the greater part of the ligature absorbed, but a small abscess had formed around the knot. Clutton has recorded a case in which the noose of the ligature was discharged from an abscess six weeks after ligature of the external iliac. Boyd had the opportunity of examining a similar ligature applied to the carotid thirty-five days before death, the wound having healed by first intention. The silk was found perfectly unchanged, surrounded by a mass of small round cells with some giant-cells. In another case recorded by Horsley a silk ligature was found unchanged after seven weeks. The connective tissue formed a strong fibrous capsule

round it, but presented here and there signs of chronic inflammation. The results of experiments on animals by Spiegelberg and Waldeyer, and Tillmanns, agree in every respect with those just mentioned.

It appears, therefore, that a silk ligature may, with proper antiseptic precautions, be safely applied and left in the wound with but little risk of its giving rise to suppuration, and with a good prospect of its being either safely encapsuled in fibrous tissue or ultimately absorbed. Further experience alone can show whether its application is more safe or more certain than that of the chromic catgut.

Ox-aorta Ligature.—In the application of the ordinary hemp or silk ligature, or of the carbolized catgut or silk, it is the object of the Surgeon, as before stated, to tie sufficiently tightly to cut through the inner and middle coats of the artery, and by the compression of the outer coat to turn their divided edges upwards and downwards into the lumen of the vessel. Some Surgeons have, however, attempted to apply a ligature in such a way as to compress all the coats without dividing any. This, as before stated, was shown by Jones to be a most dangerous proceeding if the ligature employed was of such a kind as to render it necessary that it should cut through the vessel by ulceration and so come away from the wound. The idea, however, that a vessel can be safely tied without injuring its coats has been revived in connection with the absorbable ligatures now in use. Lister at first suggested that the catgut-ligature might be applied in this way; but experience has shown that its early absorption rendered the obliteration of the vessel uncertain unless the inner and middle coats were cut. R. Barwell, however, has lately introduced a new variety of ligature prepared from the middle coat of the aorta of the ox, which he has successfully applied in a considerable number of cases without injuring the coats of the artery. The ligature is prepared by separating the outer coat and cutting the middle coat spirally into a long ribbon. This is stretched, by hanging to it a weight of from one to three pounds according to the breadth of the ligature, and allowed to dry. Ten minutes before being used it must be soaked in a 1 in 20 solution of carbolic acid in water. The breadth of the ligature makes it impossible to divide the inner and middle coats of the artery while tying it. In 1881 Barwell reported fourteen cases in which the ligature had been successfully applied to large arteries. In every case the obliteration of the vessel was successfully accomplished and nothing was seen of the ligature after the operation. Probably the same result might be obtained by the employment of very thick catgut, but the round form of the catgut makes it cut the coats of the artery more readily.

Tendon Ligatures.—Long tendons dried and afterwards carbolized have also been used as ligatures. Girdlestone of Melbourne has successfully made use of the long tendons from the tail of the kangaroo. These, however, appear to possess no advantage over properly prepared catgut.

Temporary Ligatures.—With the view of removing the various inconveniences that resulted from the presence of the ligatures in the wound, and especially with the object of promoting union by the first intention, some Surgeons attempted the use of **Temporary ligatures.**

This subject fully occupied the attention of Surgeons in this country nearly half a century ago, and has now in a great measure become matter of history, for the study of which I must refer to the writings of Jones, Travers, Velpeau,

and others. I may, however, state, that the general result of the experiments made and the experience gained on this subject is the following.

Jones found that, on cutting through the internal and middle coats of the carotid artery of a horse at three or four different points, with as many ligatures, and then *immediately* removing them, an "effusion of lymph occurred by which the artery was plugged up." These observations were not confirmed by other experimenters, such as Hodgson, Travers, and Dalrymple. But Travers found that, if the ligature were left in for several hours, or even for one hour, and then removed, obliteration of the artery ensued. Roberts applied a ligature to the femoral artery for popliteal aneurism, and, on removing it after 24 hours, found the artery closed; and Travers ligatured the brachial artery of a man, and, on removing the ligature at the end of 50 hours, obtained an equally successful result. Their example was followed by Scarpa and Paletta. Notwithstanding these favourable results, the failure of the method in the hands of Astley Cooper, Hutchinson, Béclard, and of Travers himself, and the observation of Vacca, that, if the ligature be left on the artery long enough to cause its obliteration, the section of the vessel is effected sooner or later, caused the use of the temporary ligature to be discontinued in surgical practice even by those who had at one time most strongly advocated it.

10. Acupressure.—By Acupressure is meant the occlusion of an artery by the pressure of a needle in such a way as to arrest the circulation through it or the hæmorrhage from it. This method of treatment was introduced into surgical practice by the late Sir James Simpson as a substitute for the ligature. Acupressure may be applied in several different ways; but there are four principal methods.

The *first method* is carried out in the following way, which I give as nearly

Fig. 156.—Acupressure. First Method. Raw Surface.

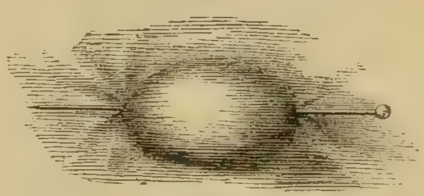


Fig. 157.—Acupressure. First Method. Cutaneous Surface.

as possible in Sir James Simpson's own words. The Surgeon places the tip of the fore-finger of his left hand upon the bleeding mouth of the artery which he intends to compress and close; holding the needle in his right hand, he passes it through the cutaneous surface of the flap, and pushes it inwards till its point projects out to the extent of a few lines on the raw surface of the wound, a little to the right of, and anterior to, his finger-tip; he then, by the action of his right hand upon the head of the needle, turns and directs its sharp extremity so that it makes a bridge as it were across the site of the tube of the bleeding artery, immediately in front of the point of the finger with which he is shutting up its orifice; he next, either with the same fore-finger of the left hand, or with the side of the extremity of the needle itself, compresses the locality of the bleeding arterial orifice and tube, and then pushes on the needle with his right hand, so as to make it re-enter the surface of the wound a little to the left side of the artery; and, lastly, by pressing the needle farther

on in this direction, its point emerges through the cutaneous surface of the flap—the site of the tube of the bleeding artery being in this way left pinned down in a compressed state by the arc or bridge of steel that is passed over it. The needle thus passes first through and from the skin of the flap *inwards* to the raw surface of the wound, and, after bridging over the site of the artery, it passes secondly from the raw surface of the wound *outwards* again to and through the skin. Sometimes the needle will be best passed by the aid of the eye alone, and without guiding its course by the finger-tip applied to the bleeding orifice. It compresses not the arterial tube alone, but also the structures placed over and around the site of the tube. When the needle is completely adjusted, all of it that is seen, and that not necessarily so, on the surface of the raw wound, is the small portion of it passing over the site of the artery (Fig. 156); while externally, upon the cutaneous surface of the flap, we have remaining exposed more or less of its two extremities, namely, its point and its head (Fig. 157). The rest of it is hidden in the structures of the flap or side of the wound. The degree of pressure required to close effectually the tube of an artery is certainly much less than Surgeons generally imagine; but in the above proceeding the amount of pressure can be regulated and increased when required, by the acuteness of the angle at which the needle is introduced and again passed out—the cutaneous and other structures of the flap serving as the resisting medium against which the needle compresses the arterial tube.

The *second method* of acupressure consists in taking a short sewing needle

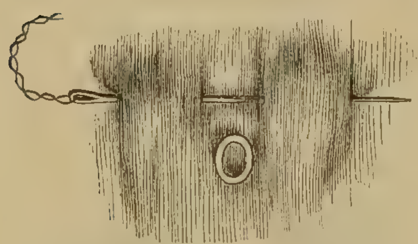


Fig. 158.—Acupressure. Second Method.

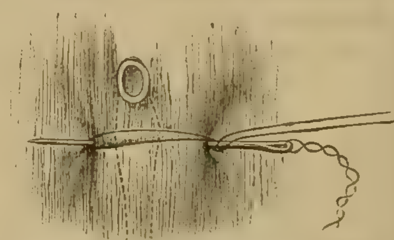


Fig. 159.—Acupressure. Third Method.

with a piece of twisted iron wire attached, for the purpose of withdrawing it when necessary. This is dipped down into the soft tissues on one side of the artery; then bridged over the vessel; then dipped down again into the soft structures on the other side of the vessel (Fig. 158). In doing this care must be taken to press the end of the needle down upon the bleeding trunk or tube of the artery with sufficient force.

The *third method* is the one that is likely to be most frequently followed, and is upon the whole the most practical and the best. It consists in compressing the artery between the needle, threaded with a piece of twisted iron wire, passed below or behind it, and a loop of inelastic iron wire passed over or above it. The needle is passed as in the last cases, but on the opposite side of the artery. The loop of iron wire is thrown over the point of the needle; it is then passed across the artery, drawn tight so as to compress the vessel, and secured by a half twist round the eye end of the needle (Fig. 159). In order to remove this apparatus, all the Surgeon has to do is to pull the twisted wire with which the needle is threaded; this, in withdrawing the needle, liberates the loop, which may then easily be removed.

The *fourth method* consists in dipping the needle into the tissues close to the artery, then making a turn with the point, and pushing this into the soft part beyond, so as to fix it there, and thus to compress the artery (Fig. 160).

The *Condition of the Artery* after having been subjected to acupressure has been determined both by experiments on animals and by observations on the human subject. It has been thus ascertained that the pressure of the needle is never sufficient to divide the internal and middle coats. Consequently, occlusion of the artery is dependent chiefly on the formation of an adherent clot within the vessel, between the point compressed and the nearest collateral branch. Some inflammatory exudation at the part that has been compressed doubtless follows the removal of the needle. This point is one of importance; for there can be little doubt that one of the safeguards after the ligature is this division of the inner coats of the artery, the consequence of which is the effusion of a plastic plug within the vessel, by which it is more effectually sealed than it can be by mere cohesion of its sides and the formation of a blood-coagulum.

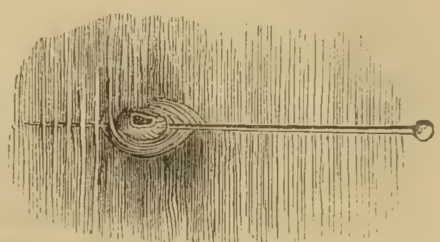


Fig. 160.—Acupressure. Fourth Method.

The time during which the needle should be left in will vary with the size of the artery, from thirty to sixty hours. The needle must not be left in too long. lest irritation be set up, and ulceration induced along its track.

Acupressure and Ligature compared.—That arterial hæmorrhage may be effectually controlled by acupressure in many cases is undoubted. This fact has long been familiar to Surgeons in the operation for hare-lip, in which the bleeding from the coronary artery is restrained by the pin that is passed across to unite the opposite sides of the cleft; and it has of late years been abundantly proved in the case of the largest arteries divided in amputations. But, though by means of acupressure arterial hæmorrhage may undoubtedly be controlled, the real question which has still to be answered is, whether we are justified in substituting this means for the ligature in surgical practice. When we reflect on the ease and certainty with which the most furious hæmorrhage from the largest artery can be at once and permanently arrested, by the tying of the mouth of the bleeding vessel—the inestimable advantage which the ligature has been and is to Surgeons, in enabling them to carry the knife with safety into regions where its presence would otherwise be fatal—we cannot lightly throw aside a means of such tried utility for one that is of doubtful value.

The arguments adduced by Sir James Simpson in favour of acupressure may be briefly summed up as follows. The great object of every Surgeon is to heal operation-wounds by the first intention; the ligature is a fatal obstacle to this, firstly because it sets up a line of suppuration in its track, and secondly because the end of the artery projecting beyond its noose forms a slough, which acts as a foreign body in the wound, and must be thrown off by suppuration. That these evils are entirely obviated, and union by the first intention is secured, 1, by the use of metallic compressors, the needle and wire being tolerated by the tissues amongst which they lie, and not acting as setons in the way that hempen or silken ligatures do; and 2, by the early withdrawal

of these compressing agents, the vitality of the artery not being endangered and no terminal slough resulting.

These arguments, though reasonable enough twenty years ago, are at the present time of no force whatever. The absorbable ligatures, now almost universally used, leave no suppurating track, and experiments have shown that the projecting end of the artery, if protected from decomposition, does not slough, but becomes embedded in the granulation-tissue formed in the healing wound, and is either absorbed or maintains its vitality, its vascular connections with surrounding parts being re-established. As before pointed out, the same is true of the twisted end of the artery left in the wound after torsion.

There is no doubt also that, even at the time when acupressure was introduced, and when every ligature caused a line of suppuration, in estimating the comparative value of the two methods of arresting hæmorrhage, too much evil was laid to the charge of the thread, and too much advantage claimed for the needle. Many other things besides the presence of a few fine silk threads tended at that time to render union of a large wound by the first intention a rare event. Drainage was very imperfectly carried out, antiseptic dressings were scarcely invented, and the hygienic arrangements of hospitals were far less perfect than they are at the present time.

Acupressure, in fact, never came into general use; but it is, nevertheless, a useful means of arresting hæmorrhage under certain circumstances. Thus, in lacerated or incised wounds of the scalp, and in some injuries of the hand or foot, in which it is difficult successfully to apply a ligature, the bleeding may often be at once controlled by the pressure of a needle and wire. Indeed, it appears to me that the Surgeon will act more wisely in being eclectic rather than dogmatic in the employment of his means for arresting arterial hæmorrhage—using in some cases styptics, in others compression or torsion or the cautery, acupressure or the ligature, as the particular case seems to need it. Because one method is good, the others are not necessarily bad; because one is peculiarly applicable in one case, it does not follow that it is equally so in all.

Collateral Circulation.—When the main artery of a limb has been ligatured, or in any other way occluded, it is only the direct flow of blood that is interrupted; the indirect supply which is conveyed into the limb or part, by the free communication between the anastomosing vessels of the different portions of the arterial system, being sufficient to preserve its vitality, and to prevent the occurrence of gangrene. So free and ready are the inosculations kept up between different portions of the arterial system, that, after the largest arteries in the body, such as the subclavian, iliac, and abdominal aorta, have been ligatured, sufficient blood to support life is at once conveyed into the parts supplied by them. This **collateral circulation** is most active and most readily maintained in early life, when the vessels are pliant and elastic, readily accommodating themselves to the increased quantity of blood that they are required to convey. As age advances, the vascular system becomes less elastic, and there is a greater difficulty in the establishment and maintenance of the collateral circulation. The anastomosing vessels which serve this purpose are invariably furnished by arteries contiguous to that which is ligatured, and come off from the same side of the body. Thus, for instance, after ligature of the superficial femoral, it is by the profunda artery that the

supply of blood is carried to the lower extremity. Thus also, when the common carotid is ligatured, the circulation to the parts it supplies is not maintained through the medium of the opposite carotid, although the inosculations between the ultimate branches of the two vessels are so free upon the throat, and the face, and within the cranium; but it is by means of the inferior thyroid and vertebral arteries (branches of the subclavian on the same side), which become greatly enlarged, that the supply of blood is kept up to the parts on the outside, as well as in the inside of the cranium.

The supply of blood that is sent to a limb, after deligation of the main trunk, is at first but small in quantity; being merely sufficient for the maintenance of its vitality, but not enough for the continuance of the usual function of the part. Hence, although the life of a limb may be preserved after the ligature of its artery, it becomes cold, and the patient is often unable to move it for some time, the muscles appearing to be completely paralysed; in a few hours, however, the supply of blood increases, until it reaches its usual standard, when the normal vigour of the part returns. By the end of twenty-four hours the limb will be found to be redder than natural, and the temperature often rises one or two degrees beyond the normal standard, whilst a great sensation of heat is experienced in it by the patient. This period of increased heat may last a week or more.

The re-establishment of the blood-supply to the limb after obliteration of the main trunk is accomplished chiefly by changes taking place in the *Anastomosing Arteries.* Almost immediately after the ligature is tightened they become dilated to their extreme capacity. This is due partly to the increased tension caused by the sudden obliteration of the main trunk, but chiefly to relaxation of their muscular coat. This relaxation is probably a reflex phenomenon consequent upon the want of blood in the parts beyond the point of obliteration of the artery. We have already seen that a similar dilatation of the vessels occurs when a limb has been rendered bloodless for a short time by an Esmarch's bandage. The dilatation is not limited to the anastomosing vessels which are directly concerned in carrying the blood from above to below the ligature, but affects the whole arterial system of the limb. It is this that causes the increased redness a few hours after the ligature has been applied. The resistance to the flow of blood is necessarily reduced to the smallest possible degree by this general vascular dilatation, and this to some extent compensates for the increased resistance which necessarily results from the blood having to be driven through a number of small anastomosing arteries, instead of through a single main trunk. The preliminary dilatation is followed by a permanent enlargement of the anastomosing arteries, which increase both in diameter and in length, and thus assume a tortuous or waved form.

Thus in a case of spontaneous obliteration of the first part of the axillary artery, met with in the dissecting-room of University College, a tortuous vessel, about the size of a crow-quill, and measuring, when straightened out, nine inches in length, was found passing from the internal mammary in the third intercostal space to the external mammary branch of the axillary. Occasionally a number of such arteries may form an interlacement. The anastomosing arteries that carry on the circulation are, as a rule, easily dissected out in a well-injected subject in the dissecting-room, and at one

time it was supposed that it was not safe to tie a large artery except in those situations in which such easily demonstrable anastomoses exist. Thus, for instance, after the ligature of the common carotid, the supply of blood is ultimately conveyed by the inosculations between the superior and inferior thyroid arteries and by the vertebral. When the subclavian is tied the circulation of the upper extremity is carried on by the anastomosis of the posterior scapular and supra-scapular, from the thyroid axis, with the acromio-thoracic and subscapular of the axillary, of the branches of the internal mammary and intercostal arteries, with the external mammary of the axillary, and of the superior intercostal of the subclavian with the superior thoracic of the axillary ; and when the external iliac is tied, the blood is conveyed to the

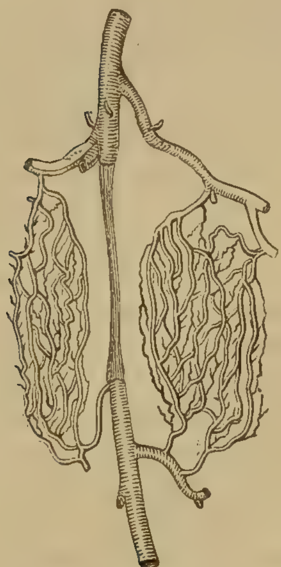


Fig. 161.—Anastomosing Circulation in Sartorius and Pectineus of Dog, three months after Ligature of Femoral. (After Porta.)

Fig. 162.—Direct Anastomosing Vessels of Right Carotid of Goat, five months after Ligature. (After Porta.)

Fig. 163.—Change in the Trunk after Ligature ; with Anastomosing Vessel.

lower limb by the inosculations between the internal mammary and lumbar arteries and the epigastric and circumflex ilii, and by those between the obturator, gluteal, and sciatic arteries and the circumflex branches of the profunda femoris.

It has, however, repeatedly been shown that the ordinary muscular and subcutaneous vessels of the part are amply sufficient to carry on the circulation, even when no anastomosing vessels can be demonstrated by dissection. As the special vessels ultimately destined to take the place of that which has been obliterated enlarge, the general vascular dilatation of the limb subsides and the circulation is practically restored to its normal condition. During the enlargement of the vessels, much pain is often experienced, owing to the pressure of the dilated vessels upon neighbouring nerves.

Jones pointed out the curious circumstance that occasionally, when two anastomosing branches approach one another, they split, before inosculating, into two or three ramusculi, which by uniting form a circle of anastomoses. Besides this kind of collateral circulation, Maunoir, Porta, and Stilling have

noticed vessels running directly between the extremities of the obliterated trunk, forming species of arterial shoots, springing from the stump of the artery (Fig. 162).

Changes that take place in the Trunk.—As a rule it is completely obliterated above and below the point to which the ligature has been applied as far as the next important collateral branch (Figs. 161, 162, 163). Beyond this, on the distal side, it is pervious and receives the blood poured into it through the different anastomosing channels. Porta and Stilling have shown that, after a time, down the centre of the fibrous cord, representing the obliterated portion of the artery, a small tortuous central canal may be developed, uniting the two parts of the vessel which are still patent.

In cases in which an absorbable ligature has been used, and in which consequently the external coat has not been divided, complete restoration of the lumen of the vessel seems to be an occasional occurrence (*vide* p. 422).

The collateral circulation is occasionally not sufficiently free to preserve the vitality of the parts supplied by it. As a consequence of this, gangrene not uncommonly results ; or the limb may become weak or atrophied. This condition may be met with in old people, from calcification and rigidity of the arterial system ; or it may happen as the result of an extensive transverse wound of the limb dividing many of the anastomosing vessels. Copious hæmorrhage by weakening the action of the heart may render it unable to overcome the increased resistance offered by the collateral circulation through which the blood has to pass, and thus the circulation may be arrested and gangrene follow. It more rarely happens that we find too great freedom of the anastomoses, so as to lead to a failure of the purposes for which the ligature has been applied, by the rapid admission of blood into the distal side of the vessel, thus perhaps occasioning secondary hæmorrhage.

Principles of Treatment of Wounded Arteries.—The principles of treatment of wounded arteries are the same whether the Surgeon adopt ligature, torsion, or acupressure. Having invariably used the ligature myself, I have here spoken of tying only, but the reader must remember that the same principles apply to all other means of arresting arterial hæmorrhage.

The whole of the doctrine of the general treatment of wounded arteries by ligature may be included in two great principles : 1. *To cut directly down on the wounded part, and to tie the vessel there ; and* 2. *To apply a ligature to both ends, if it be completely divided, or to the distal as well as the proximal side of the wound, if it be merely punctured.*

These principles of treatment were distinctly laid down by John Bell ;* but, although this great Surgeon inculcated forcibly these rules of practice, Surgeons appear to have been led away by the erroneous idea of applying the Hunterian principles in the treatment of aneurism to that of wounded arteries, until Guthrie, by his practice and precepts, and by adducing an overwhelming mass of proof to bear on this important question, recalled the attention of the Profession to the proper and rational treatment of wounded arteries.

1. The principal reason in favour of *cutting down directly upon the wounded part of the injured vessel* is, that a ligature of the main trunk at a distance above the wound stops only the direct supply of blood to the limb, but does not interfere with the indirect or anastomosing circulation, by which means

* "Principles of Surgery," vol. i., pp. 350, 390. 8vo ed.

the blood readily passes into that portion of the vessel which is beyond the ligature, and continues to escape from the distal, or perhaps even the proximal, end of the divided vessel. Thus, though bright arterial blood may no longer jet from the upper part of the wound, a continuous stream of the same colour, or of a darker tint if it has become partially deoxygenated in its passage through the anastomosing channels, will continue to well out, entailing the necessity of further operative interference to restrain its flow: and, unless this be done, the patient will die of hæmorrhage as surely, though perhaps not quite so speedily, as if no ligature had been applied. Thus, if a Surgeon endeavour to arrest the flow of blood from a wound of the ulnar artery near the palm by ligaturing the brachial in the middle of the arm, and, when the blood bursts forth as furiously as ever, apply successive ligatures to the arteries of the forearm with as little success, he will at last, on account of the continued recurrence of hæmorrhage, be forced to adopt the simple expedient that ought to have been had recourse to in the first instance, namely, that of ligaturing the vessel at the point wounded.

Another reason for the practice now advocated is, that in some cases the Surgeon cannot possibly know what artery is injured unless he seek for it in the wound itself. A large artery may, from the direction of the stab and the impetuous flow of blood that has followed it, appear to be wounded, when in reality it is only a minor branch that has been injured. Thus, for instance, in hæmorrhage from a stab in the axilla, which proved fatal, notwithstanding the ligature of the subclavian artery for supposed wound of the axillary, the long thoracic was found to be the vessel divided; so, also, the external iliac artery has been ligatured for supposed wound of the common femoral, when in reality it was the external pudic that was injured.

The rule of cutting down on the injured part of the artery applies to all cases in which the wound is still open, whatever be its condition. However deep, inflamed, and sloughy the wound—however ill-conditioned and infiltrated with pus or blood the neighbouring parts may be—it may be stated as a general rule, to which, however, there are some exceptions, especially in wounds of the palmar arch, or of the secondary branches of the carotid, that there is no safety to the patient unless the artery be cut down upon and tied at the part injured. This must always be done at any period after the receipt of the injury, so long as there is an external wound communicating with the artery. An operation of this kind is often attended with the greatest possible difficulty, not only owing to the hæmorrhage that usually accompanies it and obscures the parts, but also in consequence of the inflamed, infiltrated, and sloughy condition of the tissues in the wound. In order to moderate the hæmorrhage, the pressure of an assistant's finger on the artery high up in the limb must not be trusted to; but a tourniquet should be applied so as completely to arrest the circulation through the limb, and thus to facilitate the discovery and exposure of the injured vessel, the wound being dry. The application of an elastic bandage, such as that recommended by Esmarch, may be used with advantage to exsanguinate a limb, in which an artery has been wounded. By means of this excellent device the divided vessel may be safely cut down upon and dissected out as readily as in the dead body. A large probe should be passed to the bottom of the wound; and, taking this as the centre, a free incision should be made in such a direction as may best lay open the cavity with the least injury to the muscles and other soft parts. After turning out any coagula contained

in the wound, and clearing it as well as possible, the injured vessel must be sought for. The situation of this may sometimes be ascertained at once by the gaping of the cut in its coats ; but, in many cases, it is necessary to relax the pressure upon the artery, so as to allow a jet of blood to escape, and thus indicate the position of the aperture. The ligature may then be applied by passing an aneurism-needle under the vessel, if it be partially divided ; or, if it be completely cut across, by drawing forwards the end and tying it, as in an open wound. In doing this, care must be taken that the ligature be really applied to the vessel, and that a portion of the sheath infiltrated with blood, or thickened by adherent coagulum, be not mistaken for the artery. In applying the ligature under the circumstances here indicated, viz., in a wound that is sloughy and suppurating, the tissues will necessarily in a great degree have lost their cohesion and firmness ; and although the arterial tissue resists the disorganizing influence of inflammation much longer than areolar or muscular tissue, yet it will also have become softened and less resistant. Hence the vessel must be isolated with gentleness and care, and the ligature very carefully tied—no undue force being used. A silk ligature will usually separate in such cases several days before the ordinary time. The incisions down to the wounded artery should generally be made on the side of the wound in the vessel, and through the wound in the soft tissues covering it. Guthrie, however, advises that, in those cases in which the wound passes indirectly to the principal artery from the back or outside of the limb, the Surgeon, instead of following the track of the wound, shall cut down on the vessel where it lies nearest the surface ; then, on passing a probe through the wound, the spot at which the artery has probably been injured will be pointed out, and the ligature must be applied in the way usual in cases of primary hæmorrhage.

In *primary* hæmorrhage from wound of an artery, no operation should be undertaken unless the bleeding be actually continuing. If the bleeding have been arrested, however furious it may have been, the Surgeon should never, unless it burst forth again, search for the wounded vessel, nor undertake any operation. A man was brought to the University College Hospital with a deep stab in the groin, directly in the course of the external iliac artery ; a very large quantity of arterial blood had been lost, but the hæmorrhage was arrested on his admission by the application of pressure, &c. From the great and sudden loss of blood it was supposed that the external iliac had been punctured, but it was not thought advisable to perform any operation unless hæmorrhage recurred. The bleeding did not return, the wound healing without any further trouble. In *secondary* hæmorrhage the case is different. There the Surgeon must be prepared to secure the vessel, even though bleeding have for the time ceased.

2. The second great principle in the treatment of wounded arteries is, that a *ligature is to be applied to both ends of the vessel, if it be completely cut across; or on both sides of the aperture in it, if it be only partially divided.*

The reason for this rule of practice is founded on physiological grounds as well as on practical experience. If the anastomoses of the part be very free, as in the arteries of the palm or forearm, bleeding may continue from the distal end, uninterrupted by the ligature on the proximal side of the wound ; if they be less free, a stream of dark-looking venous blood will probably issue in the course of two or three days. After the collateral circulation has been sufficiently established, bright scarlet blood will burst forth from the distal

aperture. Experience has shown that it is in this way that secondary hæmorrhage from wounded arteries commonly occurs, the bleeding coming from the distal and not from the proximal end of the vessel.

In some cases the distal end is so retracted and covered in by surrounding parts, that it cannot be found in order to be ligatured. In these circumstances, the best effect has resulted from plugging the wound from the bottom with a graduated sponge-compress. If an arterial branch happen to be divided so close to its origin that it cannot be secured, the case must be treated as one of puncture of the main trunk, which must be ligatured above and below the bleeding orifice.

Although advocating strongly the importance of the distal as well as the proximal ligature in all cases of wounded artery, I am aware that instances are on record in which the proximal ligature alone, even at a distance from the wound, has proved successful in arresting the hæmorrhage; but I cannot but regard those cases as accidentally successful, the distal end having been better plugged than usual with coagulum; and I am strongly of opinion that the rule of practice should be that which is laid down by John Bell, and forcibly illustrated by Guthrie, viz.:—That both ends of a wounded artery be sought for, and tied in the wound itself.

ACCIDENTS AFTER ARTERIAL OCCLUSION BY SURGICAL MEANS.

The accidents that may follow the application of the ligature, the use of acupressure, or of compression in any way exercised upon wounded arteries, are Intermediate or Reactionary Hæmorrhage, Secondary or Recurrent Hæmorrhage, and Gangrene of the Limb.

Intermediate or Reactionary Hæmorrhage.—This term is limited to hæmorrhage occurring within twenty-four hours of the wound of the vessel. It most commonly occurs within a few hours of the operation.

Causes.—At the end of an operation it frequently happens that the patient is faint from the combined shock, loss of blood, and the depressing influence of the anæsthetic; at the same time the exposure of the wound to the air, and the mechanical stimulus of the knife and the sponges, have caused the greatest possible degree of contraction of the mouths of the wounded vessels. Under these circumstances, vessels of considerable size may not yield a drop of blood. As soon as the wound is closed, however, and warmly dressed, and the patient put to bed, the faintness begins to pass off, the heart beats more forcibly, the contracted vessels dilate, and hæmorrhage takes place. At the same time, if any vessel have been imperfectly tied—owing to carelessness on the part of the Surgeon, or to the use of badly-prepared rigid catgut—the knot may yield, and the ligature may slip off.

Phenomena.—As the bleeding comes as a rule only from the smaller vessels, it is seldom very profuse. It usually distends the wound, tightening the stitches, and causing the patient considerable pain.

Treatment.—The treatment is the same as that of primary hæmorrhage. If the oozing be very slight, the part may be raised and gentle pressure applied; if more abundant, the wound must be opened up, and the bleeding vessel secured. If the wound is much distended by clots, the pressure thus produced may arrest the bleeding; but it is better for the patient under these circumstances to open up the wound, turn out the clots, and secure any

vessel that may be found, as the mass of coagulum between the surfaces would form a serious obstacle to union by the first intention.

If at an operation the patient be very faint, and the smaller arteries which might be expected to bleed cannot be found, they may sometimes be made apparent by bathing the wound with carbolic lotion or water at a temperature of about 98° Fahr. In private practice it is better to do all operations if possible early in the morning, so that if reactionary hæmorrhage should occur, it may take place in the day and not in the night.

SECONDARY OR RECURRENT HÆMORRHAGE.—By Secondary Hæmorrhage is meant, bleeding which comes on after the employment of any of the above-mentioned modes of arresting hæmorrhage at any period after the first twenty-four hours. This accident may arise from a variety of causes, which may be divided first into two great classes :—Constitutional Causes; and 2, Local Causes.

Constitutional Causes.—It has already been pointed out that the healthy closure of a wounded artery is a process analogous in every respect to union by first intention; the internal coagulum serving the important purpose of protecting the soft new tissue, by means of which the mouth of the wounded vessel is being closed, from the direct impulse of the wave of blood from the heart. All those constitutional conditions which have already been described as being unfavourable to union by the first intention, are therefore equally unfavourable to the closure of a wounded artery, and consequently act as predisposing causes of secondary hæmorrhage. In some cases of *septicæmia* and in *pyæmia* the blood is found to coagulate imperfectly, and in these the internal coagulum may be more or less completely wanting, thus exposing the feeble granulation-tissue, closing the vessel, to the direct impulse of blood from the heart. In such cases, even if a clot of blood does form at first, it is liable to disintegrate and to be washed away.

In some cases secondary hæmorrhage appears to be in part due to the *forcible and excited action of the heart during the early stages of traumatic fever.* The patient is restless, and the pulse quick and bounding. In such circumstances if the bleeding be not too profuse, it sometimes appears to give relief to the symptoms.

Chronic Bright's disease, with increased arterial tension and hypertrophy of the heart, sometimes acts as a predisposing cause of secondary hæmorrhage, which is also more likely to occur in plethoric subjects, than in those of a more spare habit.

Local Causes.—These may be thus divided :—

1. *Causes dependent on the Ligature.*—If the ligature be composed of silk or hemp, and is applied in such a way as to cut through the arterial coats and to come away from the wound, it necessarily excites inflammation, reaching the stage of suppuration, and maintains the process till it has cut through the vessel by ulceration. The extent of the inflammation will depend to some degree upon the size of the ligature. If it be very fine and well waxed so as to be almost non-absorbent, the inflammation will be accurately limited to the parts in contact with the thread. If, however, it be thick and soaked in decomposing discharges, the inflammation may extend more widely and interfere with the proper development of the granulation-tissue closing the divided inner and middle coats; consequently, as soon as the process of ulceration has perforated the external coat, the blood

bursts forth. It has long been recognized that the finer the ligature, the more safely does it occlude the vessel, provided it be of sufficient strength to divide the inner and middle coats when it is tightened. The thicker the ligature, the more irritation it causes, and the more speedily it ulcerates through the external coat of the artery.

If the ligature be absorbable it should, as before stated, give rise to no suppuration in its immediate neighbourhood. It may, however, fail to prove unirritating, first if it be improperly prepared, and secondly, if it be allowed to come in contact with decomposing discharges. The absorbable ligatures present also the danger of premature softening, in consequence of which the support of the constricted external coat is taken away from the soft new tissue closing the vessel, before it is sufficiently strong to resist the blood-pressure within the artery.

2. *Causes dependent on the mode of application of the ligature.*—Secondary hæmorrhage may result from sloughing of the vessel, if, in the process of cleaning it for passing the ligature, it be too widely separated from the sheath. On the other hand, if the artery be insufficiently cleaned and other structures, as pieces of muscle or a neighbouring nerve, be included in the ligature, the vessel is seldom safely occluded; first, because its coats are not properly divided, and secondly, because of the more extensive sloughing and ulceration resulting from the inclusion of so large a mass in the noose of the ligature. With absorbable ligatures the dangers arising from imperfect cleaning are, perhaps, less, as the ligature does not separate by ulcerating through the mass included in its noose; but no Surgeon would on this account relax his endeavours to clean an artery perfectly, even when using an absorbable ligature.

The *wound of a collateral branch* immediately above the ligature, though it does not perhaps give rise to troublesome hæmorrhage at the time, will, as I have seen, cause furious bleeding as the collateral circulation becomes established.

3. *Causes dependent upon the anatomical conditions of an artery at the point ligatured.*—The *rush of blood through a neighbouring trunk or collateral branch* immediately above the ligature has been considered as likely to interfere with the formation of the internal plug; but too much importance should not be attached to this, for Porter has tied the carotid successfully within one-eighth of an inch of the brachio-cephalic artery; Bellingham has ligatured the external iliac close to its origin; and Aston Key, the subclavian in the vicinity of a large branch, without secondary hæmorrhage ensuing. But, although the ligature may be safely applied near a branch on its proximal side, I think that the presence of a collateral branch in close proximity to the *distal* side of the ligature—more especially if it be one that serves to carry on the anastomosing circulation—will be found to have a decided tendency to prevent the occlusion of the distal end of the artery, and thus to favour the occurrence of secondary hæmorrhage.

Secondary hæmorrhage is more liable to occur when an artery is tied in its continuity, than when it is completely divided. This is probably due to the longitudinal strain exerted upon the part of the artery injured by the ligature. When an artery is completely divided each end is retracted for some distance, and thus all longitudinal tension is relieved. In many arteries, such as the femoral or brachial, the strain can be relieved by placing the limb in such a position as to relax the vessel. In order to avoid this source

of danger, Abernethy, and some other Surgeons, adopted the plan of dividing the artery in every case and tying the two ends; and the practice has lately been revived by Walsham at St. Bartholomew's Hospital. Bleeding, resembling true secondary hæmorrhage, may occasionally take place some days after the artery is tied, when the collateral circulation is fully established, from the Surgeons having neglected to secure the distal as well as the proximal end.

4. *Pathological conditions of the coats of the artery.*—Atheroma and calcification of the coats of the artery will often predispose to rapid ulceration or sloughing of the vessel in the immediate neighbourhood of the ligature, which consequently separates prematurely : at the same time repair takes place less perfectly within the vessel. The danger is less with absorbable ligatures, which do not necessarily cut through the outer coat. It has happened that fatal secondary hæmorrhage has occurred from a large artery, such as the femoral, in consequence of a small atheromatous or calcareous patch having given way immediately above the ligature, a day or two after its application.

5. *Unhealthy processes occurring in the wound.*—These form by far the most common and most important causes of secondary hæmorrhage. If the end of the vessel, instead of being surrounded by healthy granulation-tissue, is in actual contact with septic pus, or if the surface of the wound be affected by some form of spreading gangrenous inflammation, as hospital, or spreading gangrene or erysipelas, it is evident that the processes of healthy repair cannot go on in it. It is by the exclusion of these unhealthy processes more than by anything else that secondary hæmorrhage is to be prevented. If the vessel is solidly sealed outside by firm granulation-tissue at the end of the third or fourth day, we may feel perfectly confident that the internal processes of repair will be safely accomplished. This can occur only if the hæmorrhage has been arrested by torsion, or some form of non-irritating absorbable ligature; otherwise suppuration must be kept up at the injured part of the vessel till the ligature is cast off. It is to be hoped, therefore, that the use of absorbable ligatures or torsion, combined with the modern improvements in the treatment, will render secondary hæmorrhage from operation-wounds one of the rarest of surgical accidents.

Phenomena.—The occurrence of secondary hæmorrhage is usually somewhat gradual, and not without warning. The blood does not burst forth in a sudden gush, but appears at first in small quantity, oozing out of the wound and staining the dressings ; it may then cease to flow for a time, probably from the opening in the artery becoming plugged by a piece of clot, but it breaks out again in the course of a few hours, welling up freely in the wound, and either exhausting the patient by repeated losses, or else debilitating him so that he falls a victim to some secondary disease, such as pneumonia, erysipelas, or pyæmia. In other cases again, after a few warnings, the blood may burst out in a gushing stream that quickly destroys life.

The opportunities which I have had of examining the state of the vessels in several cases of fatal secondary hæmorrhage, lead me fully to concur with Guthrie and Porter, that when hæmorrhage occurs from an artery ligatured in its continuity, the blood in the great majority of instances comes from the distal and not from the proximal side of the wound. The greater tendency in the distal end of the vessel to bleed, appears to arise partly from the less

perfect occlusion of this portion of the artery, and partly from its greater liability to slough, in consequence of the ligature interrupting its supply of blood through the vasa vasorum. It is no objection to this opinion that the fatal hæmorrhage is often arterial; for, though it is true that the blood which is carried to the distal end is, for the first few days after the application of a ligature, of a venous hue, yet, after the collateral circulation is once freely established, it gradually assumes a more scarlet tint, and at last becomes completely arterial.

Periods at which it occurs.—Secondary hæmorrhage may come on at any time from twenty-four hours after the operation to the closure of the wound. When the separable silk ligature is used, it is particularly apt to occur about the period of the separation of the ligature.

1. When hæmorrhage occurs *about the time of the separation of the ligature*, it may arise from any of the causes already specified as interfering with the due formation of an internal coagulum, or that occasion ulceration and sloughing of the coats of the vessel. The occurrence of hæmorrhage at this time is often connected with the rapid and full pulse accompanying septic traumatic fever in an otherwise robust and healthy patient.

2. In some cases in which *the ligature has separated, but the wound has remained open*, the hæmorrhage may take place from the cicatrix in the artery being too weak to support the impulse of the blood. Continuance of the open state of the wound after the separation of the ligature, is, most probably dependent either upon the presence of a small slough at the bottom of the wound where the noose of the ligature has lain, or upon insufficient drainage of the long suppurating track left by the ligature. The length of time that sometimes elapses between the separation of the ligature and the occurrence of hæmorrhage is very remarkable: thus, there is in St. Thomas's Hospital a preparation of a carotid artery, from which secondary hæmorrhage took place in the tenth week after ligature; and South mentions a case of ligature of the subclavian in which the thread separated on the twenty-seventh day, the fatal hæmorrhage occurring in the thirteenth week.

When an absorbable ligature is used, if from any of the causes before mentioned, it fails to become absorbed, secondary hæmorrhage may occur at the same time as with the separable ligature. It may, however, come on at an earlier period, the third or fourth day, from premature softening of the catgut, if that material be used. Experience has, however, shown that this is a very rare accident; and it can scarcely occur if the gut be properly prepared, and if it be protected from the influence of decomposing discharges.

The **Treatment of Secondary Hæmorrhage** must be considered, as the bleeding takes place, 1, from a Stump; and, 2, from an artery tied in its Continuity.

In all cases of ligature of arteries, care should of course be taken to prevent this accident, if possible, by keeping the patient perfectly quiet, giving no stimulants, having the bowels kept open and the secretions free, and avoiding any undue traction on the thread itself if a separable ligature be used.

When the pulse is full and rapid, and when from any cause the wound is suppurating and so far open that the main vessels can be seen several days after the operation beating forcibly at their further ends, there is great danger of secondary hæmorrhage occurring, and the patient must be closely watched;

the artery should be digitally compressed, and the diet lowered. In these cases it may sometimes be advisable to have recourse to venesection.

In primary hæmorrhage the rule of practice is, not to interfere by operation if once the bleeding has been arrested by other means. In secondary hæmorrhage this rule does not apply; but the Surgeon *may* proceed to adopt effectual means for the preventing a recurrence of the bleeding after the first outbreak, even though all flow of blood have ceased when he sees the patient; and he *must* do so, and that without delay, if the hæmorrhage have recurred more than once. When a repetition of secondary hæmorrhage has taken place, the patient's condition becomes most critical; the efforts of nature can no longer be relied on to arrest the bleeding, and the last and fatal gush may occur at any moment. Hence the Surgeon must in such circumstances lose no time; there must be no dallying, no hoping that the bleeding will not recur, no resorting to temporary and inefficient expedients; but the case must be at once and decisively taken in hand. In no circumstances are more coolness and more surgical knowledge required, than in adopting a decisive and immediate line of action in a case of secondary hæmorrhage. There is no time for delay, no time for consultation, none for reference to books; but the Surgeon must act at once on his own responsibility.

The treatment of **secondary hæmorrhage from a Stump** will depend in a great measure on the degree of union that has taken place between the flaps, and on the situation of the stump. When the hæmorrhage occurs a few days after amputation, if there be but slight oozing, elevating the part, applying cold, and bandaging it tightly with a roller, so as to compress the flaps, will sometimes arrest the bleeding. If it continue, however, or become more severe, the flaps, which will have been torn apart by the effusion of blood, must be separated, and the bleeding vessels sought for and tied. When the stump is sloughy, and the tissues softened, ligatures will not hold; in these circumstances, application of the actual cautery to the bleeding points will arrest the flow of blood. If the oozing appear to be nearly general from the number of points, the flaps being somewhat spongy, I have succeeded in arresting the hæmorrhage by clearing their surfaces thoroughly of all coagula, and then bringing them tightly together by means of a roller.

If the hæmorrhage occur at a later period, after the tenth day, when tolerable union has taken place, and if it appear to proceed from the principal artery of the part, an effort may be made to arrest it by the application of the horse-shoe tourniquet, which will occasionally stop all further loss of blood; or, if the union that had taken place between the flaps have been broken through, the stump may be fairly opened up, the coagula turned out, and the bleeding vessel sought for and tied. If, however, notwithstanding the hæmorrhage, the union between the flaps continue sound and firm, then the choice lies between three alternatives: 1, opening up the stump, clearing away coagula, and tying the bleeding vessels at their open mouths; 2, ligaturing the main artery just above the stump; 3, performing the Hunterian operation, and tying the vessel high up in the limb at a distance from the stump. The course to be adopted will, I think, in a great measure depend upon the stump with which we have to do; but, as a general rule, I prefer in these cases adopting the first alternative—placing a tourniquet on the limb, passing the finger into the stump, and breaking down all adhesions, which are often very firm; turning out the mass of coagula, usually found distending the flaps;

cleaning these thoroughly with a sponge, and then tying the bleeding artery. If there be a difficulty in exposing this, or in clearing it so that the ligature will hold, acupressure may be advantageously substituted for the ligature, and the effects of this may be increased by the continuous employment of digital compression in the groin. Besides the main artery that bleeds—one of the tibials, for instance, if it be a leg-amputation—there will generally be very free oozing from many points. The more abundant of this may be stopped by a ligature passed, if the tissues be friable, by means of a nævus-needle under the vessels; the rest will cease on the application of cold water and on raising the stump. The flaps may then be brought together by strips of plaster and a bandage, and will usually very readily unite.

Should, however, the stump be inflamed, sloughy, and œdematous, and more particularly if it be merely the foot or hand that has been removed, then, instead of opening it up, and seeking for the bleeding vessel, deeply hidden in infiltrated tissues, it will be better to tie the main artery of the limb just above the flaps, or wherever it can be most readily reached. In such cases, after amputation of the foot, I have successfully tied the posterior tibial low down, just above the malleolus.

The third alternative, that of ligaturing the artery high above the stump, should, I think, in the first instance, be undertaken in those cases only where the amputation has been done close to the trunk, as at the shoulder-joint, or the middle or upper part of the thigh, and where consequently there is no length of limb to be nourished by the artery that is ligatured, and where opening up an almost cicatrized stump of very large size would inflict a greater shock upon the system, and more subsequent danger, than the deligation of an artery by an independent operation. Hence, although in no case of secondary hæmorrhage from a leg-stump below the knee would I ligature the femoral in preference to opening up the flaps and securing the vessels in them, if this were practicable, yet in secondary hæmorrhage after amputation of the thigh, the case might be different; here, if good union had already taken place, and the stump were not distended by coagula, the main artery might be tied. In such cases it is clearly useless to ligature the superficial femoral, as the hæmorrhage may proceed from some of the branches of the profunda. Ligature of the common femoral, although at one time considered an unsafe operation, has recently been frequently performed with success, and might be done under these circumstances, although I have myself usually preferred to tie the external iliac just above Poupart's ligament. In disarticulation of the arm at the shoulder-joint, the subclavian artery must be tied, either above or just below the clavicle.

In any case, ligature of the main artery of the limb becomes the only and the last resource, when, in consequence of the softened, inflamed, infiltrated or sloughy state of the tissues the Surgeon is unable to secure the bleeding vessels in the stump itself, the ligatures cutting through the disorganized coats of the vessels.

2. When the hæmorrhage occurs after a ligature has been applied to the **Continuity of the Vessel**, whether for injury or disease, pressure must first be tried. With this view the wound should be plugged, and a graduated compress should be very firmly and carefully applied by means of a ring-tourniquet over the point from which the blood proceeds; in this way the bleeding may occasionally be stopped. Not unfrequently, however, this will prove

ineffectual, the bleeding recurring from underneath. When this is the case, what should the Surgeon do? He may re-apply the compress once more with great care, after clearing away coagula, and drying the parts thoroughly; but should it again fail in arresting the bleeding, it is useless to trust to it further, as the hæmorrhage will certainly recur, and valuable time and much blood will be lost in these fruitless attempts at checking it. In such a case as this, the Surgeon must clearly and decidedly determine on the course to be pursued, as there is but "little time for reflection or consultation, and none for referring to authorities."

If the artery be situated on the trunk, as the subclavian, carotid, or one of the iliacs, there is nothing to be done but to trust to the plugging of the wound; and in the great majority of these cases the patient will die exhausted by repeated hæmorrhage.

When the artery is situated in one of the limbs, more efficient procedures may be employed. If it be one of the arteries of the upper extremity, the wound should be opened up, and an attempt made again to tie both ends of the vessel in this; should this fail, or not be practicable, the artery must be deligated at a higher point than that at which it had been previously tied; should the hæmorrhage continue, or recur, amputation is the only resource left.

In the lower extremity, the treatment of secondary hæmorrhage occurring after ligature is replete with difficulty. Here I believe it to be useless to tie the artery at a higher point than that to which the ligature has been already applied, as gangrene is very apt to follow this double ligature of the arteries of the lower extremity: at least, in the two or three cases that I have seen in which recourse has been had to this practice, mortification of the limb has ensued; and in all the reported cases with which I am acquainted, a similar result has occurred. The treatment should vary according as we have the femoral artery or one of the tibials to deal with. If the hæmorrhage proceed from the femoral, I should be disposed to cut down on the bleeding part of the vessel, treating it as a wounded artery, and applying a ligature above and below the part already deligated; this operation would, however, necessarily be fraught with difficulty. Should it be impracticable, or not succeed in checking the hæmorrhage, we should best consult the safety of the patient by amputating at once on a level with or above the ligature. Although this is an extreme measure, it is infinitely preferable to allowing him to run the risk of the supervention of gangrene, which will require removal of the limb under less favourable conditions. If the secondary hæmorrhage proceed from one of the tibials, it would be next to useless to adopt either of the preceding alternatives. If we ligatured the superficial femoral, the bleeding would not be permanently controlled, or, if it were, gangrene of the limb would in all probability set in. There are but very few cases on record in which this practice has been followed without mortification occurring. In a few rare instances, however, ligature of the popliteal has, in such circumstances, succeeded: but it has also frequently failed, rendering secondary amputation necessary; so its success is a mere matter of chance. The depth at which the tibials are situated is so great, that it would be hopeless to search for one of these vessels and attempt its deligation at the bottom of a deep, sloughy, infiltrated and inflamed wound. In such circumstances, therefore, I think we should amputate the leg above the seat of wound. This is truly a severe measure; but

the only other alternative that has, to my knowledge, ever succeeded, is ligature of the popliteal; and as that, as already stated, has frequently failed, I think that, as a rule, we should best consult the safety of the patient by the removal of the limb at once.

If the hæmorrhage occur from a wounded artery to which ligatures have already been applied above and below the seat of wound, the same treatment must be adopted as in those cases in which the bleeding takes place from a vessel tied in its continuity.

Gangrene following Ligature.—After the ligature of the main artery of a limb, the collateral circulation is, under all ordinary circumstances, sufficient to maintain the vitality of the part supplied by the deligated vessel. In some cases, however, it happens that the condition of the circulation in the parts below the ligature is not compatible with their life.

The *Period of Supervention* of gangrene of the limb extends over the first three or four weeks after the ligature of the vessel. It seldom sets in before the third day, but most frequently happens before the tenth.

Causes.—The causes influencing the occurrence of gangrene in this way are the Age of the Patient, the Seat of the Operation, and various Conditions in which the limb may afterwards be placed.

The influence of *age* is not, however, so marked as might *à priori* be supposed; for, although there can be no doubt that there is a less accommodating power in the arterial system at an advanced period of life to varying quantities of blood, and that there would be greater difficulty in maintaining the vitality of a limb after ligature of its artery in a man of sixty than in one of twenty-five; yet I find that, of thirty cases in which gangrene of the lower extremity followed the ligature either of the external iliac or femoral arteries, the average age of the patient was thirty-five years, as nearly as possible the mean age at which these operations, according to Norris's Tables, are generally performed. Of these cases of gangrene two occurred in persons under twenty years of age, eleven between twenty and thirty, eight between thirty and forty, and nine above forty.

The *seat of the operation* influences greatly the liability to gangrene, which is much more frequent after the ligature of the arteries in the lower than in the upper extremity.

Besides these predisposing causes, gangrene after ligature may be directly occasioned by a *deficient supply of arterial blood*. In some cases this may arise from the collateral vessels being unable, in consequence of the rigidity of their coats, to accommodate themselves to the increased quantity of blood which they are required to transmit; or they may be compressed in such a way by extravasation as to be materially lessened in their capacity. In other instances again, the existence of cardiac disease may interfere with the proper supply of blood to the part.

Great *loss of blood*, either in consequence of secondary hæmorrhage, or in any other way, before or after the application of the ligature, is often followed by gangrene, and is almost certain to be attended by this result if a second ligature have been applied to a higher point in the lower extremity. That a diminution in the quantity of blood circulating in the system may, under the most favourable circumstances, become a cause of gangrene after the ligature of a main artery, is illustrated by the statement of Hodgson that, soon after the introduction of the Hunterian operation into Paris, it was the custom to employ repeated

venesection in the cases operated on; the consequence of which was, that mortification was of frequent occurrence.

A more common cause of gangrene is the *difficulty experienced by the venous blood in its return from the limb.* This difficulty always exists even when no mechanical obstacle impedes the return, being dependent on the want of a proper *vis a tergo* to drive on the blood. The propulsive force of the heart, the main agent in the venous circulation, is largely expended in driving the blood through the narrow and circuitous channels of the anastomosing vessels. This difficulty to the onward passage of the venous blood may, if there exist any cause of obstruction in the larger venous trunks, be readily increased to such an extent as to arrest the circulation, and so cause the limb to mortify. This mechanical obstacle may be dependent upon the occlusion of the vein by thrombosis occurring within it opposite the ligature, by its transfixion with the aneurism-needle, or by its accidental wound with the knife in exposing the artery. When such an injury, followed by inflammation, is inflicted on a vein, which, like the femoral, returns the great mass of blood from a limb, gangrene is almost inevitable.

The supervention of *erysipelas* in the limb after the application of a ligature, though fortunately not of very frequent occurrence, is a source of considerable danger, being very apt to give rise to gangrene by the tension of the parts obstructing the anastomosing circulation. I have on two occasions seen gangrene of the fingers, from this cause, follow ligature of the vessels of the fore-arm.

Abstraction of heat from the limb, either directly by the application of cold, or indirectly by the neglect of sufficient precaution to keep up the temperature of the part, often occasions gangrene: thus Sir A. Cooper saw mortification follow the application of cold lead-lotion to a limb in which the femoral artery had been tied; and Hodgson witnessed the same result when the operation was performed at an inclement season of the year.

The *incautious application of heat* may, by overstimulating the returning circulation of the limb, especially about the period when the rising temperature is an indication of distension of the capillary vessels, occasion mortification. In this way the application of hot bricks and bottles to the feet has given rise to sloughing; and Liston was compelled to amputate the thigh after ligature of the femoral artery, for gangrene induced by fomenting the limb with hot water.

The *application of a bandage,* even though very cautiously made, is apt to induce sloughing and gangrene. I have seen this happen when a roller was applied to the leg after ligature of the femoral artery, with a view to removing the œdema.

Character.—The gangrene from ligature of an artery is almost invariably of the moist kind, as it usually arises from diminished *vis a tergo* and consequent stagnation of blood. The limb first becomes œdematous; vesications then form; and the skin assumes a purplish or greenish-black tint, rapidly extending up to the seat of operation. In some cases, though they are rare, simple mummification of the limb comes on; the skin assuming a dull yellowish-white hue, mottled by streaks that correspond to the veins, and becoming dry, horny, and shrivelled, about the extensor tendons of the instep.

Treatment.—Much may be done with the view of preventing gangrene. Thus, the limb should be slightly elevated, wrapped up loosely in cotton-

wadding, and laid on its outer side after the operation. If the weather be cold, hot-water bottles may be put into the bed, but *not in contact with the limb.* Should there be any appearance of stagnation of venous blood, the plan recommended by Guthrie of employing continuous and methodical friction in a direction upwards for twenty-four hours, so as to keep the superficial veins emptied, may be practised.

When mortification has fairly set in, amputation of the limb should be performed at once as the only chance of saving life, in all those cases in which the patient's constitutional powers are sufficiently strong to enable him to bear the shock of the operation. The limb should be removed at the seat of the original wound, or opposite the point at which the artery has been tied. In those cases, however, in which the gangrene follows injury of the femoral artery just below Poupart's ligament, Guthrie advises that the amputation should be done below the knee, where the gangrene usually stops for a time. If the gangrene spread, with œdema or serous infiltration of the limb, the amputation should be done high up—at the shoulder-joint, or in the upper third of the thigh. In these cases a large number of vessels usually require ligature, having been enlarged by the collateral circulation.

CHAPTER XV.

TRAUMATIC ANEURISM AND ARTERIO-VENOUS WOUNDS.

TRAUMATIC ANEURISM.

We have hitherto discussed the treatment of an injured artery having an open wound communicating with it. It often happens, however, that the case is not so simple as that which has been described, but that, in addition to the wound in the vessel, there is subcutaneous extravasation of blood, with more or less pulsation, thrill, and bruit, from the projection into it of blood from the wounded vessel. This extravasation constitutes a **Traumatic Aneurism**, and may arise in three ways. 1. There may be an oblique or indirect puncture into the artery, the blood furnished by which partly escapes from the wound, partly extravasates itself into the tissues around the vessel. 2. The puncture in the integuments may have been closed by plaster or bandage ; and then no blood escaping externally, although the wound in the artery continues patent, the blood is forced out into the substance of the limb or part. 3. There may have been no external wound, but the artery may have been punctured or torn across subcutaneously, by the fragments of a fractured bone, by a violent strain or twist of the limb, by the injury inflicted in a dislocation, or by the Surgeon in his efforts to reduce it.

These traumatic aneurisms, in whatever way arising, are of two kinds, the *Diffused* and the *Circumscribed*.

Diffused Traumatic Aneurism.—This consists of an effusion of blood poured out by a wounded or ruptured artery with which it communicates ; limited in extent by the resistance of surrounding parts, and partially coagulating in the meshes of the areolar tissue. It has no sac ; and its ill-defined boundary, composed partly of coagulum, partly of inflammatory exudation from the tissues into which the blood is poured out, has a constant tendency to extend under the pressure of the fluid blood, which continues to be projected into the centre of the tumour.

This form of traumatic aneurism is indicated by a subcutaneous, soft, and semi-fluctuating tumour, often of very considerable size. If the communication be large the tumour increases rapidly in size, and this gives rise to the most intense pain. At first the skin covering it is of its natural colour, but it gradually becomes bluish, and is thinned by the pressure to which it is subjected. If the wound in the vessel be rather large, there will be a distinct pulsation in the tumour synchronous with the systole of the heart, accompanied by a thrilling, purring, or jarring sensation, and often a distinct and loud bruit. In other cases, if the injured artery be small, or if the wound in it be oblique, and of limited size, there may be no distinct pulsation or bruit ; the tumour being either indolent and semi-fluctuating, or having an impulse communicated to it by the subjacent artery. In those cases also in which the artery is torn completely across, or in which the effused blood co-

agulates very rapidly, the ordinary aneurismal bruit and pulsation may be very obscure or quite absent. In such cases, the diagnosis is often extremely difficult. From the redness of the skin, the œdema of the subcutaneous tissue, the rapid formation of the tumour, and the acute pain, a diffused traumatic aneurism closely resembles an acute abscess, and many cases are on record in which an incision has been made into it under this supposition. The true nature and gravity of the tumour may usually be recognized by observing that the pulse in the arteries at a lower point is absent, that there is great œdema of the limb from pressure on the veins accompanying the artery, and that the tumour is situated in the line of one of the main arterial trunks. The immediate relief experienced by the patient when the main trunk above the tumour is compressed may in some cases aid in the diagnosis, but too much reliance must not be placed upon this, as the pain of an acute abscess may be to some extent relieved in the same way. In cases in which the diagnosis cannot be otherwise made the aspirator may be used. If pure blood is withdrawn in large quantities, the diagnosis of aneurism would be confirmed; if only a few drops of blood escaped it would be uncertain, as these might come from the inflamed tissues round an abscess; if pus mixed with blood appeared in the syringe it might still be an aneurism if the tumour had existed any length of time, as suppuration might be taking place round the extravasated blood.

These tumours, if left to themselves, rarely undergo spontaneous cure, but they either increase in size until the integument covering them sloughs and ruptures, or the external wound, which has been temporarily plugged by coagulum, gives way; or else they inflame and suppurate, pointing at last, like an abscess, and, on bursting, give rise to a sudden gush of blood, which may at once, or by its rapid recurrence, prove fatal. The combined obstruction to the flow through the artery and the pressure on the veins may cause gangrene of the limb at an early stage of the case. In some cases the boundary of clotted blood and inflammatory exudation may give way, and the loss of blood extravasated into the areolar tissue beneath the fascia of the limb may be so great as to cause death from syncope.

Treatment.—The treatment must be conducted on exactly the same plan as that of an injured artery communicating with an external wound; the only difference being that, in the case of the diffused traumatic aneurism, the aperture in the artery opens into an extravasation of blood instead of upon the surface. We must especially be upon our guard not to be misled by the term *aneurism*, and not to attempt to treat this condition, resulting from wound or subcutaneous laceration, by the means that we employ with success in the management of aneurism proper. In a pathological aneurism the blood is contained within a sac, which, as will hereafter be shown, is essential for the process of cure of the disease. In the diffused traumatic aneurism there is no sac, properly speaking; and hence those changes to which a sac is necessary cannot take place. I doubt whether there is a case on record in which the Hunterian operation for aneurism, applied to the condition now under consideration, has not terminated in danger or death to the patient, and in grievous disappointment to the Surgeon.

The proper treatment of diffused traumatic aneurism consists in laying open the tumour by a stroke of the scalpel, removing the coagula, dissecting or rather cleaning out the artery, and ligaturing it above and below the wound in it. This operation, easy in description, is most difficult and tedious in

practice. The bleeding is often profuse ; the cavity that is laid open is large, ragged, and partially filled with coagula ; it is often with much difficulty that the artery is found under cover of these, and in the midst of infiltrated and disorganized tissues ; and when it is found, it is not always easy to get a ligature to hold. It will be convenient to divide the operation into two stages:—1. Exposing the artery ; 2. Passing the ligature.

First Stage.—The limb should be rendered bloodless and an india-rubber tourniquet applied, whenever this is possible. If the artery can be so commanded, the diffused aneurism may be at once laid open freely ; but if not, the Surgeon must proceed more cautiously. He must make a small aperture in the most prominent part of the tumour, and introduce two of the fingers of the left hand so as to plug the wound in the integuments, and prevent the escape of blood, at the same time feeling for the opening in the artery, and pressing his finger well upon this. Having ascertained that he controls the vessel thoroughly by the pressure of his left index- and middle fingers, he may proceed to slit open freely the wound in the integuments, and clear the clots and blood thoroughly out of the aneurismal tumour.

Second Stage.—The Surgeon will now have exposed the deep part of the aneurismal cavity. The artery must next be cleaned for the application of the ligature. If the artery be commanded above by an elastic tourniquet the Surgeon carefully searches for the opening in the vessel. If he cannot find it the elastic tourniquet must be removed and the artery controlled either by a screw tourniquet or by the fingers of an assistant. The opening can then be readily found by allowing a jet of blood to escape. Having found the opening he can proceed to clean the artery. This may best be done by passing a steel probe, or, what is better, a full-sized bougie or sound, into the open wound in the artery so as to distend the vessel, dissecting down on each side of this through the posterior wall of the sac, and then passing the ligature in the usual way. But if the vessel be so near the centre of the circulation that it cannot be efficiently commanded, then the difficulties become far greater. Under these circumstances the Surgeon must, if possible, replace the finger with which he is closing the wound in the artery by that of an assistant, so that he may have both hands free to clean the artery. The change must be made instantaneously to avoid loss of blood. If, however, he cannot do this he must, while keeping the fore-finger of his left hand firmly pressed on the open wound, endeavour, by scratching through the tissues above it, to expose the artery sufficiently to make a dip with the needle around it, and thus to secure it. This part of the operation is by far the most difficult in such cases, on account of the infiltration of the parts and the thickening of the structures preventing the artery from being readily distinguished and easily cleared.

The application of a ligature to the distal end of the vessel, if it be completely divided, is especially difficult. Should it not be practicable, the application of the actual cautery, or pressure by means of a sponge-tent or graduated compress, will be found the best means of arresting the hæmorrhage.

Circumscribed Traumatic Aneurism differs entirely from the diffused in its pathology and treatment, inasmuch as it possesses a distinct sac. There are two varieties of this form of aneurism.

1. In the first variety, a puncture is made in an artery, or the vessel is ruptured subcutaneously, as perhaps in the reduction of an old dislocation ; blood is extravasated into the adjoining tissues ; and, if there be an external

aperture, this cicatrizes. The blood that is extravasated becomes surrounded and limited by inflammatory exudation. This may be followed by the gradual development of fibrous tissue, as in the process of the formation of a scar. There is thus formed a distinct fibrous sac, the tissue of which, although sufficiently firm to prevent any diffusion of the blood, is not strong enough to resist the distending force of the heart; it consequently slowly yields, and the tumour increases in size. The yielding of the sac is not a process of simple stretching, for it does not become proportionally thinner as it increases in size; it is accompanied by a constant growth of new fibrous tissue. As the aneurism increases, however, and produces more and more irritation by its pressure, and consequent inflammation of the surrounding parts, the growth of the fibrous tissue is less perfect, and finally becoming too soft to withstand the pressure of the blood, the sac may rupture and the aneurism become diffused. The sac is externally adherent to the surrounding parts, internally it is soon lined by layers of fibrine deposited from the blood that passes through it. This tumour, usually of moderate size, and of tolerably firm consistence, pulsates synchronously with the beat of the heart, and has a distinct bruit, both of which cease when the artery leading to it is compressed. This form of circumscribed traumatic aneurism most commonly occurs from punctured wounds of small arteries, as the temporal, plantar, palmar, radial, and ulnar.

The **Treatment** to be adopted depends upon the size and situation of the artery with which the tumour is connected. If the artery be small, and so situated that it can be opened without much subsequent inconvenience to the patient, as on the temple or in the fore-arm, it should be laid open, the coagula turned out, and the vessel ligatured above and below the wound in it. If the tumour be so situated, as in the palm, that it would be difficult and hazardous to the integrity of the patient's hand to lay it open, the Hunterian operation for aneurism should be performed, as was successfully done in a case (Fig. 164) in which the brachial was ligatured for an aneurism of this kind in the ball of the thumb, following serious injury to the hand from a powder-flask explosion. When it is connected with the superficial palmar arch I have, however, successfully adopted the old operation of laying the tumour open, taking out coagula, and ligaturing the artery at the seat of injury.

Fig. 164. — Circumscribed Traumatic Aneurism in Ball of Thumb after a Powder-flask Explosion.

It is but rarely that this form of traumatic aneurism is connected with a large artery; when it is, the vessel may be ligatured above, but close to the sac, in the same way as in the next variety. If this form of traumatic aneurism have increased greatly in bulk, so that the skin becomes thin and discoloured, or if inflammation ensue, and symptoms of impending suppuration take place around it, then it would be useless to ligature the artery above the tumour, as this would certainly give way, and secondary hæmorrhage follow. Here the proper course is to lay open the sac, turn out the contents, and tie the artery above and below the part that is wounded.

2. The next form of circumscribed traumatic aneurism is of rare occurrence,

and arises usually from a small puncture in a large artery, as the axillary or the carotid. The vessel bleeds freely; but, the hæmorrhage being arrested by pressure, the external wound and that in the artery close. The cicatrix in the artery gradually yields, forming, at the end of weeks or months, a tumour which enlarges, dilates, and pulsates eccentrically, with distinct bruit, having all the symptoms that characterize an aneurism from disease, and having a sac continuous with the outer coat and sheath of the vessel. It is at first soft and compressible on being squeezed, but becomes harder and firmer, and cannot be so lessened after a time. It consists of a distinct circumscribed sac, formed by the yielding of the cicatrix in the external coat and sheath of the artery, no blood being effused into the surrounding tissues.

The **Treatment** will vary according to the size of the tumour. If this be small or but moderate in size, it consists in the ligature or compression of the artery leading to the sac, in accordance with the principles that guide us in the treatment of aneurism from disease; though, from the healthy state of the coats of the vessel, the artery may be ligatured as near as possible to the sac.

As there is a distinct cyst or sac in these circumscribed aneurisms, the changes that will be described in the chapter on the Treatment of Aneurisms in general take place; the tumour gradually becoming consolidated, and eventually absorbed. Should, however, the aneurism have attained an enormous magnitude, or should it, from being circumscribed, have become diffused by the rupture of the sac, then the tumour must be laid freely open, the coagula turned out, and the artery ligatured as in the ordinary diffused aneurism.

ARTERIO-VENOUS WOUNDS.

A wound in an artery may communicate with a corresponding one in a contiguous vein, giving rise to two distinct forms of disease—*Aneurismal Varix* and *Varicose Aneurism*. These preternatural communications, which were first noticed and accurately described by W. Hunter, were common formerly at the bend of the arm, as a consequence of the puncture of the brachial artery in bleeding; but they have been met with in every part of the body in which an artery and vein lie in close juxtaposition, having been found occurring as a consequence of wounds of the subclavian, radial, carotid, temporal, iliac, femoral, popliteal, and tibial arteries. The two forms of disease to which the preternatural communication between arteries and veins gives rise, differ so completely in their nature, symptoms, effects, and treatment, that separate consideration of each is required.

Aneurismal Varix results when, a contiguous artery and vein having been perforated, adhesion takes place between the two vessels at the seat of injury, the communication between them continuing pervious, and a portion of the arterial blood being projected directly into the vein at each beat of the pulse. Opposite to the aperture of communication between the two vessels, which is always rounded and smooth, the vein will be found to be dilated into a fusiform pouch, with thickened coats. The veins of the part generally are considerably enlarged, somewhat nodulated, tortuous, and thickened. The artery above the wound is dilated; below, it is usually somewhat contracted. These pathological conditions are evidently due to a certain quantity of the arterial blood finding its way into the vein, distending and irritating it by its pressure, and less consequently being conveyed by the lower portion of the artery.

The **Symptoms** consist of a tumour at the seat of injury, which can be emptied by pressure upon the artery leading to it, or by compressing its walls. If subcutaneous, this tumour is of a blue or purple colour, of an oblong shape, and will be seen to receive the dilated and tortuous veins. It will be found to pulsate distinctly with a tremulous jarring motion, rather than a distinct impulse. Auscultation detects in it a loud and blowing, whiffing, rasping, or hissing sound, usually of a peculiarly harsh character. This sound has very aptly been compared by Porter to the noise made by a fly in a paper-bag, and by Liston to the sound of distant and complicated machinery. The thrill and sound are more distinct in the upper than in the lower part of the limb, and are most perceptible if the limb be allowed to hang down so as to become congested. Besides these local symptoms, there is usually some muscular weakness, together with diminution in the temperature of the part supplied by the injured artery.

Treatment.—As this condition, when once established, is stationary, all operative interference should be avoided, an elastic bandage merely being applied. Should a case occur in which more than this is required, the artery must be cut down upon and ligatured on each side of the wound in it. Holmes suggests that in aneurismal varix a cure might possibly be obtained by pressure directed solely to the orifice in the vein.

VARICOSE ANEURISM.—In this case the openings in the artery and vein do

Fig. 165.—A Varicose Aneurism at the Bend of the Arm unopened.

not directly communicate (see Figs. 165 and 166), but an aneurismal sac is formed between the two vessels, into which the blood is poured before passing into the vein.

The **Pathological Condition** of this form of injury consists in the forma-

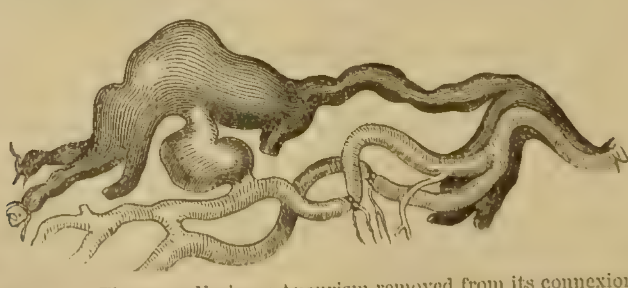


Fig. 166.—The same Varicose Aneurism removed from its connexions.

tion of a circumscribed traumatic aneurism, communicating on one side with the artery, and on the other with the vein, which is always in a state of varix. A varicose aneurism is, in fact, a circumscribed traumatic aneurism *plus* an

aneurismal varix. This condition is well represented in the annexed cuts, from drawings of Sir C. Bell's, in the museum of University College, representing a varicose aneurism before and after it had been opened (Figs. 165 to 168). In this case there appears to have been a high division of the brachial, and a communicating branch below the wound, between the radial and ulnar; in consequence of which, as Mr. Shaw informs me, the tumour pulsated as forcibly after the artery had been tied as before, the blood finding its way

Fig. 167.—The same Tumour laid open, showing the Circumscribed False Aneurism between the two Vessels.

back through the aneurism into the veins. Gangrene of the hand and arm followed.

Symptoms.—In the symptoms of varicose aneurism, we have a combination of the characters of aneurismal varix and of the circumscribed traumatic aneurism; there is a pulsating tumour, at first soft and compressible, but,

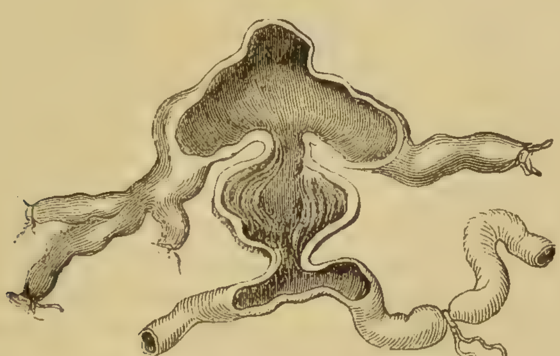


Fig. 168.—The opened Tumour removed from its Connexions.

after a time, assuming a more solid consistence, in consequence of the deposition of fibrin within it: superficial to this tumour, the vein that has been punctured is dilated into a fusiform pouch, presenting the ordinary characters of varix. The sounds heard in these tumours are of two distinct kinds: there is the peculiar buzzing thrill that always exists where there is a preternatural communication between an artery and vein; besides this there is a blowing or bellows sound, dependent on the aneurism. These signs are most perceptible when the limb is in a dependent position; and the sounds can often be heard in the veins at a considerable distance from the seat of injury. There is also some impairment in the nutrition and temperature of the parts supplied by the injured vessels. As the disease advances, the aneurismal tumour lying between the artery and vein continues to increase in size, and to become hardened by the deposition of laminated fibrine. If left to itself, it would

probably continue to enlarge until sloughing of the integuments covering it occurred, followed by hæmorrhage. In some cases, the aperture of communication between the vein and sac becomes closed, and the tumour is converted into a simple circumscribed traumatic aneurism.

Treatment.—The treatment of this disease must be conducted on different principles from those that have been laid down as required in the ordinary circumscribed traumatic aneurism ; the difference depending upon the fact, that in the varicose aneurism there is always a double aperture in the sac, and that thus the proper deposition of laminated fibrin necessary for its occlusion cannot take place. The sac of such an aneurism may be compared to one that has been ruptured, or accidentally opened, in which we could consequently not expect the occurrence of those changes that are necessary for the cure of aneurism by the Hunterian operation.

In a varicose aneurism, consequently, the sac must be freely incised, and the artery tied on each side of the puncture in it. This procedure may, unless the Surgeon be careful, and properly understand the pathology of this disease, be attended by some difficulty (Fig. 167). The operation will, however, be greatly simplified by exsanguinating the limb by means of the elastic roller and the tourniquet. If this device be adopted, the Surgeon will be able to see clearly what he is about. After the first incision has been made through the integuments, the dilated vein will be laid open, and an aperture will be seen at the bottom of the vessel, from which arterial blood may be made to issue by relaxing the tourniquet. If an attempt be made to find the artery immediately below this aperture, the Surgeon will be disappointed, for the sac of the circumscribed aneurism intervenes between the two vessels. That this aperture leads into the sac, and not into the artery, may readily be ascertained by introducing a probe into it, which will be seen to be capable of being carried sideways, as well as upwards and downwards, to a considerable extent, and in different directions altogether out of the course of the artery. In order to expose this vessel properly, a probe-pointed bistoury must be introduced into this opening, and the sac of the false aneurism slit up to its full extent, the coagula turned out, and the puncture in the artery sought for in the bottom of the cavity that has been exposed ; this may now readily be made visible by the escape of a jet of arterial blood on relaxing the pressure on the upper part of the artery ; a ligature must then be passed above and below the opening.

Vanzetti has recorded a case of varicose aneurism of the brachial artery cured in six hours by **digital compression**, applied simultaneously to the artery above the tumour, and to the orifice leading from the sac into the vein. Franzolini cured a case in the same way, after sixty days' compression, at irregular intervals. In Fischer's tables are twelve cases of varicose aneurism, nine of which were cured by digital compression. In at least four of these cures it was applied as above described. It seems therefore that digital pressure is a hopeful mode of treating such cases.

CHAPTER XVI.

WOUNDS OF SPECIAL BLOOD-VESSELS.*

VESSELS OF THE HEAD AND NECK.

Carotid Artery.—**Wounds of the Carotid Artery**, and of its primary and secondary divisions, are more frequent in civil practice than similar injuries of any other set of arteries in the body, in consequence of the neck being frequently the seat of suicidal attempts. The hæmorrhage from wounds of the main trunk is so copious as often to be immediately fatal. In the event of a Surgeon being at hand, both ends of the bleeding vessel must be at once ligatured. Should the jugular vein be also wounded a ligature must be applied, if possible, by pinching up the wound and applying the thread in such a way as not to completely occlude the vessel. Should the hæmorrhage, whether primary or secondary, proceed from a deep branch of the external carotid, as the internal maxillary, so situated as not to admit of the vessel being exposed and ligatured at the seat of wound, the ordinary rule of practice of tying a wounded artery at the seat of injury must be departed from, and the main trunk be tied at the most convenient spot. Considerable difference of opinion has existed as to whether, under these circumstances, it is better to tie the external or the common carotid. Guthrie strongly advocated the application of the ligature to the external carotid, but most Surgeons have preferred to tie the common trunk above the omo-hyoid, fearing that the application of a ligature amongst the numerous branches of the external carotid would be followed by secondary hæmorrhage. The results of this operation, however, have been far from satisfactory; not only have many patients died directly from the operation itself, but in a very large proportion the hæmorrhage for which it was performed has recurred and proved fatal. Harrison Cripps has collected 50 cases of ligature of the common trunk for hæmorrhage, 28 of which terminated fatally. He therefore advocates a return to Guthrie's practice of applying the ligature to the external carotid, and the exact point he recommends is between the superior thyroid and the lingual. This operation is not difficult of performance, and seems in itself to be less dangerous than the deligation of the main trunk. Madelung has collected the records of 60 cases, of which only 7 died. There seems every reason therefore for preferring it, when possible, to the more serious operation of tying the common trunk.

Internal Carotid.—If the internal carotid is wounded, ligature of the common carotid gives the best chance of recovery.

In consequence of the speedy fatality of the wounds of the carotid artery and its branches, **Traumatic Aneurisms** are rarely met with in this situation; they do, however, occasionally occur, and the records of surgery contain at

* A full description of the operations required for the ligature of the various arteries will be found in Vol. II., Chapters XLIII. and XLIV.

least six instances of the kind, in each of which the common carotid was tied, and the patient ultimately recovered.

Aneurismal Varix in the Neck, dependent on puncture of the **Internal Jugular Vein and Carotid Artery**, usually the result of sword-thrusts, is apparently of more frequent occurrence than traumatic aneurism in this region; probably owing to the close proximity of the vein rendering it difficult for the artery to be wounded on the outer or anterior sides, without first perforating that vessel. The symptoms offer the general characteristics of aneurismal varix, but have several points that are worthy of special remark. The wound of the vessels has been in every instance followed by the effusion of a large quantity of blood into the loose areolar tissue of the neck; the extravasation acquiring the size of even a child's head, and threatening immediate suffocation. As this extravasation subsided, the ordinary characters of aneurismal varix began to manifest themselves. The period at which these symptoms first made their appearance varied somewhat in the different cases, but they always occurred within four or five days of the receipt of the injury. In none of the cases did the disease appear to shorten life, or to occasion any dangerous or inconvenient effects, with the exception of some difficulty in lying on the affected side, and occasional giddiness or noise in the head on stooping. No operation is permissible in these affections.

Varicose Aneurism is very rarely met with in this situation. There is indeed only one case on record. It was situated close to the skull, and resulted from a bullet wound.

TEMPORAL ARTERY.—**Traumatic Aneurism of the Temporal Artery**, and of its branches, occasionally occurs as the result of partial division of these vessels in cupping on the temple. I have met with two cases of this kind, in both of which the disease was readily cured by laying the tumour open, turning out its contents, and tying the artery on each side of it.

INTERNAL MAXILLARY.—This artery is occasionally injured and wounded in gun-shot wounds. If the hæmorrhage is too copious to be restrained by cold or styptics, the external or common carotid must be tied.

LINGUAL ARTERY.—This vessel is occasionally injured in gun-shot wounds. If the Surgeon can be perfectly certain that the blood is coming from the lingual, he may tie that vessel above the hyoid bone (See Diseases of the Tongue); otherwise it is better to ligature the external or common carotid.

VERTEBRAL ARTERY.—**Wounds of the Vertebral Artery** occasionally occur as the result of stabs in the neck; and several cases of traumatic aneurism in this situation have been recorded. In these wounds there is a danger of mistaking the source of the hæmorrhage, as pressure on the carotid, if made below the transverse process of the sixth cervical vertebra, arrests the flow of blood in the vertebral as well, which, up to this point, lies immediately beneath it. This transverse process is at least two inches above the clavicle, and lies much higher than one is apt to think. There are no less than eleven cases on record, in which the carotid has been tied for a wound of the vertebral, in consequence of this mistake. When the wound of the artery is situated between two transverse processes, ligature is almost impossible, and the Surgeon will be obliged to trust to plugging the wound, and to the use of styptics. The recorded cases of this injury are fully reviewed by Holmes in his lectures on the Surgical Treatment of Aneurism.

VESSELS OF THE TRUNK.

Internal Mammary.—Wounds of this artery rarely come under treatment, as its course lies chiefly in front of the heart and great vessels, so that penetrating wounds implicating it are usually immediately fatal from injury to the parts beneath. The *treatment,* in case the patient escapes fatal injuries to deeper parts, is to tie the artery at the wounded spot, if necessary removing a costal cartilage in order to expose it. No other treatment is likely to arrest the bleeding, because of the free anastomoses with the intercostals.

Intercostal Arteries.—These are rarely wounded except in gunshot-fractures or stabs fracturing a rib. The hæmorrhage is seldom severe; but should it require *treatment,* the lower border of the rib corresponding to the artery must be exposed by a free incision. On removing the fragments the bleeding artery may come into view, and can be twisted or tied; or it may be turned out of its groove by means of a periosteal elevator, and sufficiently exposed to be tied. If necessary, a piece of rib may be removed to expose the vessel more fully. As a temporary means of arresting hæmorrhage, pressure may be applied in the following way. A piece of linen is to be pushed through the wound into the pleural cavity, so as to form a pocket inside; a sufficient quantity of lint or tow is pushed into the pocket to make it too large to pass out by the intercostal space; it is then forcibly pulled upon by the part of the linen outside the chest-walls, and secured in position by a couple of pins pushed across the neck on a level with the skin.

VESSELS OF THE UPPER LIMB

Subclavian Artery.—A **Wound of the Subclavian Artery** may be looked upon as almost invariably fatal; though, in consequence of the manner in which the vessel is protected by the clavicle, this injury can scarcely occur except from gun-shot-violence or stabs. From the rapidly fatal nature of wounds of the subclavian artery, **Traumatic Aneurisms** in this situation are not met with; but where the artery passes into the axilla below the margin of the first rib, they are not unfrequent.

Aneurismal Varix, resulting from wound of the *Subclavian Artery and Vein,* has been seen, notwithstanding the separation that exists between the two vessels throughout their whole extent. These injuries have likewise usually been the result of sword-thrusts, and do not admit of any surgical interference.

Axillary Artery.—In **Open Wounds of the Axillary Artery and of its Branches,** the rule of practice consists in cutting down upon the bleeding vessel and ligaturing it on each side of the wound. It must be borne in mind that, the arterial branches given off between the lower edge of the first rib and the fold of the axilla being very numerous, a punctured wound of the axilla or side of the chest may injure one of these vessels; though from its course, and the free flow of arterial blood that has followed the stab, it may be supposed that the axillary artery itself has been punctured. The particular vessel injured can be ascertained only by following up the wound, and ligaturing the artery that furnishes the blood; and in order to do this successfully it may sometimes be necessary to divide the pectoralis major and minor across the line of their fibres.

In some cases, however, the state of the parts may be such, that it may be impossible to trace the artery at the depth at which it is situated, or even to expose it in a more superficial situation, as in the stump after amputation at the shoulder-joint. In these circumstances, the rule of ligaturing an artery at the seat of injury may be departed from, and the main trunk should be tied either above or below the clavicle; and the success of this operation has been sufficient to justify our having recourse to it, rather than exhaust the patient by any prolonged attempts at the ligature of the vessel in the open wound, though I think that this ought first to be attempted. Of 15 cases in which the artery was ligatured either above or below the clavicle, for hæmorrhage from wounds in the axilla or from stumps, I find that 9 were cured and 6 died. Although the success is about equal in whichever situation the vessel be tied, I should certainly give the preference to the supraclavicular operation, owing to the greater facility of its performance, and the comparative absence of collateral branches at the seat of ligature. In some cases, however, especially after amputations at the shoulder, the clavicle is pushed up at its acromial end, and then the artery might be best reached below the clavicle, under or through the pectoral muscles.

Traumatic Aneurism in the Axilla is not of unfrequent occurrence, arising from gun-shot-wounds, or from the thrust of a knife, sabre, or other pointed weapon. In some cases the injury arises from a subcutaneous rupture of the vessel, the patient stretching out and straining his arm in an attempt to save himself from falling, and feeling a sudden snap in the axilla, which is followed rapidly by the formation of a diffused aneurism.

There are several cases on record in which axillary aneurism has resulted from violent attempts made by Surgeons in the reduction of old-standing dislocations of the head of the humerus. Thus Pelletan mentions a case of this kind, in which the tumour, being supposed to be emphysematous, was opened, and the patient perished of hæmorrhage. Warren relates a case of diffused axillary aneurism resulting from rupture of the artery, in consequence of the Surgeon attempting to reduce a dislocation of the humerus by using his foot as a fulcrum in the axilla, but without taking off his boot. Gibson has related three cases of axillary aneurism following rupture of the artery, in the attempt to reduce old-standing dislocations with the pulleys. These cases are of much interest to the Surgeon, as showing the necessity for great caution in the use of powerful extending force in the reduction of old dislocations, adhesions having possibly formed between the artery and head of the bone.

In those cases of diffused traumatic aneurism of the axilla that arise from subcutaneous rupture or laceration of the artery, the condition of parts is essentially the same as in the case of an open wound of the vessel, with the exception of the absence of any external aperture in the integuments. In these cases a tumour of considerable size, hard or fluctuating, according to the state of coagulation of its contents, forms with more or less rapidity. If it have formed very quickly, the artery being torn across, and the blood coagulating as it is effused, it will not present the ordinary aneurismal signs, but may merely resemble an ordinary extravasation; from, this, however, it may be distinguished by the loss of the pulse at the wrist, and by the œdema of the arm. If it form slowly, the blood continuing fluid, there will be the usual signs of aneurism, such as thrill, and pulsation. In all these cases, there is much

œdema of the arm, with a tendency to inflammation, suppuration, and sloughing of the tumour and the parts amongst which it lies, with perhaps gangrene of the limb itself.

Some of these traumatic axillary aneurisms have a tendency to diffuse themselves with great rapidity, filling up the whole of the hollow of the armpit, extending under the pectoral muscles, and even up around the shoulder. In other cases again, when more circumscribed, the disease may get well spontaneously, as happened in cases recorded by Van Swieten, Sabatier, and Hodgson. In other instances again, the disease has remained stationary for years, or has undergone consolidation under medical treatment. It cannot, however, be considered sound practice to leave a traumatic aneurism of this artery without surgical interference, after the ordinary dietetic and hygienic plans of treatment have failed in effecting a cure, for it may at any time become rapidly diffused, or inflame and suppurate.

The *Treatment* of traumatic axillary aneurism must depend on the question whether it be diffused or circumscribed.

When a *diffused traumatic aneurism* of recent origin, rapid formation, and dependent upon puncture of the artery, is met with in the axilla, the treatment must be conducted in the same way as that of a wounded artery, without extravasation, in this situation. As Guthrie very justly observes, it can make no difference whether the puncture in the skin has healed or not—the condition of the artery must be the same. The tumour should be laid open, the coagula turned out, the artery sought for, and ligatured where wounded. There is, however, danger after this operation, either of secondary hæmorrhage coming on from the seat of wound, by blood conveyed through the collateral vessels which open into the subscapular and circumflex arteries; or else of the limb falling into a state of gangrene. In either case, amputation at the shoulder and through the aneurismal extravasation is the only practice that holds out a chance of life to the patient.

In diffused traumatic aneurism of the axilla from subcutaneous rupture or laceration of the axillary artery, the choice would lie between treating the injury by direct incision, and ligaturing the vessel above the clavicle. The ligature of the vessel above the clavicle has been done three times, with only one recovery, two of the patients dying of gangrene and secondary hæmorrhage. In the successful case, secondary hæmorrhage had occurred; and gangrene of the arm, which threatened, was prevented, and the patient saved, by amputation at the shoulder-joint. The result, therefore, of ligature is so little promising, that few Surgeons would be disposed, in the face of these facts, to repeat this operation.

The only other alternative consists of treating the ruptured artery on the same principle as a wounded one, disregarding the accidental complication of the subcutaneous accumulation of a few ounces of blood. This undoubtedly is the proper surgical principle on which to act in these cases. Its adoption has been strongly urged by Guthrie, and its advantage has been demonstrated by the success attending it in several cases in which it has been adopted by Paget, Syme, and others. The operation consists in compressing the subclavian above the clavicle, either by the pressure of the finger from the surface, or, as was done by Syme in his case, by previously making an incision over it, through which it could be more readily commanded; then laying the tumour open by a free incision through the anterior fold of the axilla and the pectoral

muscles, turning out the coagula, and seeking for and ligaturing both ends of the artery ; for it must be remembered, that the distal extremity of the torn vessel will probably bleed freely, owing to the open anastomoses round the shoulder.

Circumscribed Traumatic Aneurisms of the Axillary Artery are not uncommonly of slow formation, existing for several months or years before they require operation, although resulting from punctured wound of the arm-pit. In chronic cases of this kind, the aneurism is necessarily provided with a firm and distinct sac, and approaches closely in its characters to the pathological form of the disease.

The *Treatment* here cannot be conducted on the principles that guide us in the management of a wound, or of a diffused aneurism of recent occurrence of this artery ; for not only is the circumscribed aneurism provided with a sac, but the vessel at the point injured will very probably be found to have undergone changes that render it little able to bear the application of the ligature. It will be softened, thickened, and lacerable, with perhaps a wide funnel-shaped aperture leading into the sac, which will be closely incorporated with the neighbouring parts. But, indeed, the treatment of this form of circumscribed traumatic aneurism by the ligature of the artery on the proximal side of the sac, has been found to be attended with remarkable success. In eight recorded cases in which this operation has been performed, not one fatal result has been noted. In all, the aneurism arose from stabs or gun-shot-wounds, and had existed for various periods, between two weeks and four years. In four of the cases the artery was ligatured above, and in four below the clavicle : and in one case of each category there was suppuration of the sac.

The particular point at which the artery should be ligatured must depend upon the condition of the tumour. If this be of large size, or arise from the upper part of the axillary artery above or immediately below the pectoralis minor muscle, there is no choice but to deligate the vessel above the clavicle. Should, however, the principal increase in the tumour take place in a direction downwards and forwards under the great pectoral muscle, the portion of the artery immediately below the clavicle not being covered by the sac, the question would arise as to whether this part might not be selected for the application of the ligature; and as the results of both operations have hitherto been equally favourable, this must rather be determined by the peculiarities in each case than on more general grounds. Most Surgeons, I think, would generally prefer ligaturing the artery above the clavicle, as being a simpler proceeding than tying it below that bone ; which, moreover, has the disadvantage of bringing the scalpel into very close proximity with the sac, which, were it to stretch upwards under the pectoralis minor to a greater extent than could be discernible externally, might possibly be opened by the knife, as has happened in operating even above the clavicle.

Compression of the artery on the distal side of the tumour succeeded in curing the disease in a case that was under Goldsmith of Vermont.

Brachial Artery.—The hæmorrhage from **Wounds of the Brachial Artery** may sometimes be arrested by the employment of methodical compression, but usually it requires the ordinary ligature on each side of the aperture.

This vessel may occasionally be punctured in venesection. This accident, which was formerly of frequent occurrence when venesection was practised by

professed phlebotomists, now very rarely happens. Should a Surgeon be so unfortunate as to meet with this accident, the best practice is to cut down upon the artery at once and apply a ligature above and below the wound, and at the same time to tie the wounded vein. Should he not have at hand the means of doing this, he may perhaps prevent injurious consequences by keeping up a proper degree of pressure, by means of a graduated compress applied immediately on the occurrence of the accident. With this view, the hand, and fore-arm having been very carefully padded and bandaged, a well-made graduated compress should be firmly applied over the seat of puncture, and retained there for at least ten days or a fortnight. Should the aperture in the artery not be closed in this way, either a circumscribed false aneurism, a varicose aneurism, or an aneurismal varix will form, according to the relation of the puncture in the artery to that in the vein.

In the **Circumscribed Traumatic Aneurism** at the bend of the arm, following a wound of the brachial artery, we have the usual soft or semi-solid pulsating tumour, which can readily be emptied by pressure, and possesses more or less bruit. This disease may be *treated* in one of three ways: 1, by compression upon or above the tumour; 2, by ligaturing the artery leading to it; or 3, by cutting through the sac, and deligating the vessel on each side of the aperture in it.

The compression of the tumour has often been successfully practised. It may be done by means of a graduated compress on the tumour, and the application of a ring-tourniquet over the artery: the tumour becoming consolidated, and gradually undergoing absorption. In employing compression great care must be taken, however, not to induce sloughing of the tissues over the tumour by sudden and too forcible pressure. The limb should be carefully bandaged and maintained in the semi-flexed position. Should this plan not succeed, we must be guided in our ulterior measures by the particular conditions of the case. If the tumour be of recent origin, soft and compressible, or, though of longer duration, large, with a thin sac, and in danger of becoming diffused, it should be treated by direct incision, and the artery be deligated on each side of the wound in it. Should, however, the tumour be small, or of but moderate size, and the sac be tolerably thick and firm, so as to admit of the deposit of laminated fibrine, we may treat it by deligation of the brachial artery, either in the middle of the arm, or, as Anel did with success, immediately above the tumour. In the event, however, of the disease not being cured in this way, incision of the sac must be had recourse to, as I have known to be necessary in a case in which the brachial artery was tied above the sac, which was large and thin—the pulsations returning in a few days, and the tumour continuing to enlarge.

Varicose Aneurism, at the bend of the arm, presents the ordinary character of the disease. Occasionally, though rarely, it would appear that the aperture of communication between the aneurismal sac and the vein becomes closed, and thus the varicose is converted into the ordinary circumscribed traumatic aneurism.

The *Treatment* of this affection must be conducted on different principles from that of the ordinary circumscribed variety; for whatever be the density of the sac, it is never, as has already been explained (p. 452), a perfect one, having always an opening into the vein which would prevent its proper closure by the deposit of laminated fibrine. In four cases related by Sabatier,

which were treated by Anel's operation, amputation became necessary in two; and, in the other cases, the operation by incision of the sac was required before a cure could be effected. The sac must therefore be laid open, and the vessel tied on each side of it in the way that has been recommended in the treatment of varicose aneurism, and with the caution there laid down. If the varicose aneurism be converted, after a few days, into the circumscribed form, the aperture into the vein becoming occluded, ligature of the artery above the sac may be successfully employed, or compression may succeed in curing the disease.

In **Aneurismal Varix** of the arm, a roller and compress are all that can be required.

VESSELS OF THE FORE-ARM AND PALM.—**Wounds of the arteries of the fore-arm** are very commonly caused by pieces of glass or earthenware, or by knives. In every case the bleeding point must be cut down upon, and both ends of the vessel tied. This rule is peculiarly imperative in this situation, on account of the freedom of the anastomosis through the palmar arches. In many of these cases the bleeding is at first very free, but, being arrested by pressure, does not break out again until eight or ten days have elapsed; when, the arm being much infiltrated with blood, inflamed, and swollen, double ligature of the vessel at the seat of injury has to be practised under somewhat difficult and unfavourable circumstances.

Traumatic Aneurism of the Radial and Ulnar Arteries usually assumes the circumscribed form, owing to the pressure employed at the time of injury confining the extravasation. If it be small and recent, and situated superficially at the lower part of the fore-arm, or if it be in any way diffused, the better plan is to cut down upon and through the tumour at once, ligaturing the vessel on each side. If, however, the aneurism be deeply seated amongst the mass of muscles at the upper part of the fore-arm, near the elbow-joint, the wound having healed, and the soft parts covering it being healthy and firm, the advice given by Liston appears to be most judicious:—rather than cutting through the muscles and detaching their connections, he recommends that the aneurism should be left to attain some consistence, and then that the brachial artery be secured in the mid-arm. In such cases as these, also, compression of the brachial, with moderate pressure on the tumour itself, has effected a cure.

In a case of traumatic aneurism of the lower end of the radial, just above the wrist, that recently came under my care, the aneurism had twice been laid open; the upper end of the radial had been tied; but attempts made to secure the distal end of the artery had been ineffectual, the result being a return of the aneurism, though in a small and more circumscribed form. This I cured by the application of pressure, by means of a small screw-tourniquet attached to a splint, to the radial artery where it lies between the extensor tendons of the thumb; the recurrent aneurism in this case being entirely fed by blood brought to its distal side through the deep palmar arch.

Wounds of the Palmar Arches not unfrequently occur from the breaking of glass or china in the hand, or stabs from some pointed instrument, and are always troublesome to manage. If the Surgeon sees the case shortly after the infliction of the wound, he may endeavour, by enlarging the aperture to a moderate extent, and with due attention to the tendons and nerves of the part, to secure the bleeding vessel. If it be the superficial arch that is

wounded, no difficulty will be found in securing it; but if it be the deep, he will very likely fail. In some cases the artery can be seized in a pair of forcipressure forceps, which may be left in the wound for twenty-four hours and then carefully removed. Under any circumstances, no effort should be spared to secure the vessel without using the graduated compress. One of the chief dangers of incisions into the palm of the hand is the occurrence of septic suppuration, extending to the synovial sheaths of the flexor tendons. In order to prevent this, it is very important that such wounds should be treated antiseptically, thoroughly well drained, and preserved from every source of irritation. A graduated compress by its pressure causes considerable irritation, and interferes seriously with drainage. Moreover, if a compress is applied with sufficient force to stop the flow of blood through the artery, it must necessarily render the whole area it presses on bloodless. If, therefore, a compress be applied efficiently, and kept on, as is sometimes recommended, for three or four days, it must inevitably cause gangrene of the tissues with which it has been in contact; or, supposing the tissues are not quite dead, acute inflammation will set in as soon as the blood is admitted to them. This has but too often been the experience of Surgeons after the use of the compress; when it has been removed, a foul sloughy wound has been brought into view, with diffuse inflammation spreading round it. Under these circumstances the artery cannot be safely occluded, and secondary hæmorrhage is very likely to occur.

Still, if all other means fail, the Surgeon must fall back on the graduated compress, which, if well and firmly applied, will often succeed in arresting the bleeding. If it be loosely and ineffectually put on, it will be worse than useless. The proper mode of putting on this compress is as follows. A tourniquet having been applied on the brachial artery, the wound must be carefully cleared of all foreign bodies, and wiped dry; each finger is then to be separately and carefully bandaged. A wooden splint is then to be put on the back of the hand and the lower part of the fore-arm. A firm well-made graduated compress is now to be placed with the apex downwards on the wound, so as to bring and press the edges together, and securely bandaged against it by a separate bandage. The patient should then be put to bed with the hand elevated. At the end of eighteen to twenty-four hours the bandage may be carefully removed without disturbing the splint or the compress, and re-applied with just sufficient force to keep the compress in position sticking to the wound without pressing strongly enough to empty tissues beneath of blood. It is sometimes recommended that the circulation through the limb should be controlled by a ring-tourniquet, applied on that artery above the wrist which appears most to correspond with the arch wounded, or better still, on the brachial itself; or the elbow may be forcibly flexed, and the fore-arm bandaged to the arm in this position, so that the hand rests upon the shoulder. These precautions are, however, unnecessary, if the compress is properly applied; but they may with advantage be made use of after the bandage has been relaxed. The compress may be left undisturbed for five or six days, unless there be redness, swelling, and pain, indicating the formation of pus beneath it, when the sooner it is taken off the better. Should the wound be found healing and looking well, there need be no fear of further hæmorrhage; but should the palm be sloughy and infiltrated, there will be a considerable risk of the bleeding recurring. Under these circumstances, it is useless again to resort to compression, and other means must be employed.

Should an ineffectual attempt have been made to arrest the primary hæmorrhage, or should the case not be seen until several days have elapsed, when secondary hæmorrhage has occurred, and the palm has become infiltrated and swollen, pressure can no longer be borne upon the seat of injury, and it is useless to endeavour to search for the injured vessel in the midst of sloughy and infiltrated tissues, through a narrow wound which cannot be enlarged without danger of seriously injuring the hand. In these circumstances, it is necessary to deviate from the ordinary rule of practice in wounded arteries, and the Hunterian operation must be performed. The Surgeon may either tie both arteries above the wrist, or at once deligate the brachial. Both methods of treatment have their advocates. I prefer the simultaneous ligature of the two arteries of the fore-arm, just above the wrist, where they are superficial and very easily reached. In several cases under my care, the radial and ulnar, immediately above the hand, have been tied at the same time with complete success, and I have never seen a case in which this operation has failed; but should hæmorrhage occur after it, as might happen in the case of an enlarged median or interosseous artery, the Surgeon must have recourse to compression or ligature of the brachial.

Circumscribed Traumatic Aneurism in the Palm is by no means of frequent occurrence. It may, however, follow wounds of the palmar arches. In such a case as this, it would be clearly out of the question to lay open the sac, and to search for the injured vessel in the midst of the aponeurotic and tendinous structures of the hand. It would consequently be necessary, either to tie the radial and ulnar arteries immediately above the wrist, or to ligature the brachial in the middle of the arm. The latter plan should be preferred; as, were the first mode of treatment put into practice, the sac might continue to be fed by the interosseous artery, as happened in a case of Roux's, in which the patient died of hæmorrhage from the palmar aneurism after ligature of both arteries of the fore-arm. In the case represented (Fig. 164) Liston successfully ligatured the brachial in the mid-arm, after compression upon it had failed to effect a cure.

VESSELS OF THE LOWER LIMB.

GLUTEAL ARTERY.—**Traumatic Aneurisms of the Gluteal Artery** are of less frequent occurrence than might *à priori* have been imagined, from the situation of the vessel exposing it to injury. These aneurisms may acquire an enormous size. In John Bell's celebrated case, the tumour is said to have been of "prodigious size," and to have contained eight pounds of blood. In Syme's case the tumour was as large at the base as a man's head, occupied the whole hip, and rose into a blunt cone.

The *Treatment* that should be adopted in these cases is to compress the aorta by means of the aortic tourniquet; then to lay open the tumour freely, turn out its contents, and pass a ligature by means of an aneurism-needle round the short trunk of the gluteal as it emerges from the pelvis.

FEMORAL ARTERY.—The hæmorrhage from the **Femoral Artery, Common, Superficial or Deep**, when wounded is always very profuse. In all cases, ligature of the wounded vessel at the seat of injury should, if possible, be practised.

If a **Diffused Traumatic Aneurism** have already formed, the artery should be commanded by a tourniquet, as it passes over the brim of the pelvis, the

sac laid open, and the bleeding vessel sought for and tied. Guthrie has collected a great number of cases, which prove incontestably that the general principles of treatment in wounded arteries must not be departed from, when the arteries of the groin or thigh are wounded. On the contrary, the facility with which in most cases the circulation is kept up, and the readiness with which secondary hæmorrhage comes on as a consequence of the free anastomoses in this situation, render the rule of practice of applying a ligature on each side of the wound in the vessel peculiarly stringent in all recent arterial wounds in this part of the body. Secondary hæmorrhage and gangrene of the limb are the great sources of danger here. When gangrene is imminent, or has come on, amputation is necessarily the sole resource. With regard to secondary hæmorrhage supervening after ligature of the artery *at the seat of injury*, there is, I think, no safe course but removal of the limb. Where the artery has been tied higher up, as, for instance, when the external iliac has been ligatured for recent wounds or traumatic aneurisms in the groin or upper part of the thigh, the hæmorrhage appears to have returned, or gangrene to have supervened in all these cases. This fact was remarkably illustrated in the Crimean War. Thus, Macleod states that the French in one hospital at Constantinople ligatured the femoral at a distance from the wound for secondary hæmorrhage seven times, and that all the cases failed.

If the traumatic aneurism have assumed a *circumscribed* character, it must be treated on the principles laid down for this form of the disease, the supplying artery being ligatured above the tumour ; and cases are not wanting in proof of the success of this practice.

It occasionally, though rarely, happens that a **Varicose Aneurism** is formed in the groin or upper part of the thigh, as the result of wound of the artery and vein in this situation. It usually presents the ordinary characters of this disease, but some peculiarities have occasionally been met with. Thus, in a case related by Horner, there was a wavy motion in the femoral vein on the uninjured side, arising from the blood in the wounded vessel communicating a thrill upwards to that contained in the vena cava. In a case related by Morrison, it is stated that a tumour, as large as the human uterus at the third month of pregnancy, communicated with the injured vein.

The *Treatment* of this disease is exceedingly unsatisfactory. Of four cases in which the external iliac artery was tied, a fatal termination occurred in every instance ; two of the patients dying of gangrene of the limb, and the remaining two of secondary hæmorrhage and consecutive pneumonia. It has consequently been proposed by Guthrie that the tumour be laid open, and the artery secured above and below the aperture in it. As this plan has never been fairly put into practice, it would perhaps be useless to speculate on the chances of success likely to attend it. The danger of a fatal gush of blood on laying open the sac, which in former times would have made most Surgeons hesitate to venture on such an operation, has now been completely obviated by the use of the aorta-compressor.

Vessels of the Leg and Foot.—Deep stabs, cuts, and gun-shot-wounds of the leg may be followed by profuse hæmorrhage from a wounded artery. It may not always be easy to determine with accuracy which of the arteries is wounded : whether it be one of the tibials, the peroneal, or only large muscular branches. This is more especially the case when, in consequence of fracture, a pulsatory extravasation of blood forms in the calf. When there is an open

wound, the direction taken by it will probably enable the Surgeon to solve the question.

In the *Treatment* of arterial bleeding from the leg—whether calf or front—the Surgeon may, especially if it be not very profuse, try to arrest it by compress, bandage, and position. Should these modes fail, recourse must be had to operation.

When the **Posterior Tibial Artery** is wounded, there is no reason to deviate from the usual principle of treating primary hæmorrhage from a wounded artery, viz., to cut down on the vessel at the seat of injury, and tie it above and below the wound in it. The same rule of treatment applies to **Wounds of the Anterior Tibial and Peroneal Arteries.** In performing this operation, if the posterior tibial be wounded in the upper two-thirds of its course, the Surgeon will have to cut freely by the side of, or through, the muscles of the calf. This he must do in the direction of their fibres, injuring them by transverse incision as little as possible; and, by taking the track of the wound as his guide, the bleeding vessel will at last be reached, and must then be tied in the usual way. Such an operation practised on a person with a muscular limb that is infiltrated with blood and inflammatory effusions, is in the highest degree difficult. In the lower third of the leg the arteries are superficial, and reached with comparative ease.

When the hæmorrhage is not primary, but *consecutive*, or if a diffused aneurism have formed, with or without external wound, as in the case of fracture, Surgeons have occasionally had recourse to ligature of the superficial femoral artery, with success. The artery may be tied in Scarpa's triangle, or, which would, I think, be better in such a case, in Hunter's canal. When ligature fails, amputation is necessarily the only resource. In one of the successful cases S. Cooper ligatured the popliteal—a plan that has found favour with the French Surgeons. In another, Dupuytren tied the superficial femoral for a pistol-bullet-wound in the leg. The others were cases of diffused aneurism, arising from a secondary hæmorrhage occurring in the course of a fracture.

The subject of **Wound of the Tibial Arteries** as a result of fracture of the tibia, will be more fully discussed in Chapters XX. and XXI.

Small **Circumscribed Aneurisms** are occasionally met with in the foot, in consequence of wound of one of the plantar arteries, as in operations for club-foot. If pressure have failed in preventing or curing the disease, the only course left to the Surgeon is to lay the tumour open, and to ligature the artery on each side in the usual way.

Wounds of the Plantar Arteries must be treated on the same principles as are wounds of the palmar arches.

CHAPTER XVII.

ENTRANCE OF AIR INTO VEINS.

The Entrance of Air into a Wounded Vein, though an accident of rare occurrence, is one that occasions such peculiar and alarming symptoms, that it becomes necessary to be acquainted with the circumstances attending it; and its study is the more interesting to the practical Surgeon, as it is chiefly in the course of operations that this condition occurs.

In surgical practice, we meet only with *spontaneous admission* of air into the circulation. This was first observed in the year 1818, in a case in which the internal jugular vein was opened during the removal of a large tumour from the right shoulder by Beauchesne. The investigation of this subject is consequently a comparatively recent matter, in which the labours of the Commissioners of the French Academy are conspicuous, and the names of Magendie, Amussat, Cormack, and Wattmann are distinguished.

Results of Experiments on Animals.—As cases of entry of air into the veins occur comparatively seldom in man, it is necessary to study the phenomena accompanying it on the lower animals. It has long been known to physiologists that the forcible introduction of air into the circulation would kill an animal; and Morgagni, Valsalva, Bichat, and Nysten have made this a subject of observation and experiment. The death of the animal in these cases appears to be dependent partly on the quantity of air injected, and partly on the rapidity with which it is thrown in. Bichat supposed that a single bubble injected into the circulation killed the animal with the rapidity of lightning; but this is erroneous, as shown by Nysten. I have on several occasions injected two or three cubic inches of air into the jugular vein of a dog, without producing death, though much distress resulted. The rapidity with which the air is thrown in exercises a considerable influence upon the result. If blown in quickly, a small quantity may kill; if thrown in slowly and gradually, a large quantity may be injected without destroying life, the blood appearing to absorb and carry away the gas. In experiments which I made many years ago on this subject, I have observed the following phenomena in cases where death was produced.

On exposing the internal jugular vein low in the neck, and puncturing it at a place where the flux and reflux of the blood are plainly discernible, there is perceived in the first inspiratory effort made by the animal after the wound, a peculiar lapping or gurgling-liquid, hissing sound; the nature of the sound depending partly on the size and the situation of the opening in the vessel. At the same time, a few bubbles of air are seen to be mixed with blood at the orifice in the vein. The entrance of the air is immediately followed by a struggle, during the deeper inspirations of which, fresh quantities of air gain admittance, the entrance of each portion being attended by the peculiar sound above described. On listening now to the action of the heart, a loud churning

noise will be heard, synchronous with the ventricular systole ; and the hand will, if applied to the parietes of the chest, feel at the same time a peculiar bubbling, thrilling, or rasping sensation, occasioned by the air and blood being, as it were, whipped together amongst the columnæ carneæ and chordæ tendineæ. As the introduction of air continues, the circulation becomes gradually more feeble and languid ; the heart's action, however, being fully as forcible as natural, if not more so. The animal soon becomes unable to stand ; if placed upon its feet, it rolls over on one side, utters a few plaintive cries, is convulsed, extrudes the fæces and urine, and dies. If the thorax be immediately opened, it will be seen that the heart's action is continuing regularly and forcibly, and that the pulmonic cavities, though filled, do not appear distended beyond their ordinary size.

Death occurs, as I have shown in a paper on this subject, published in the 158th number of the *Edinburgh Medical and Surgical Journal*, in consequence of the air and blood being beaten up together in the right cavities of the heart into a spumous froth, which cannot be propelled through the pulmonary vessels ; hence there is a deficient supply of blood to the brain and nervous centres, and fatal syncope comes on, attended usually by convulsions. In addition to this, the frothy mixture in the ventricles has not sufficient resistance to press upon and to close the valves of the heart, and the organ soon comes to a stand-still.

Spontaneous Entry of Air into the Veins of Man is attended by two distinct sets of phenomena, one of a local, the other of a constitutional character.

Local Phenomena.—These consist of a peculiar sound, produced by the entrance of the air, and of the appearance of bubbles about the wound in the vein. The sound is of a hissing, sucking, gurgling, or lapping character, and never fails to indicate the serious nature of the accident that has occurred. When once heard, whether in man or in the lower animals, it can never be mistaken. It has fortunately fallen to my lot to hear this sound in the human subject on one occasion only, in a patient who had attempted suicide by cutting his throat. The wounded internal jugular was being raised for the purpose of having a ligature passed under it, when a loud hissing and gurgling sound was heard, and some bubbles of air appeared about the wound ; the patient became faint, and greatly oppressed in his breathing. The ligature was immediately tightened, the faintness gradually passed off, and no bad consequences ensued.

The **Constitutional Effects** are usually very marked. At the moment of entry of the air, the patient is seized with extreme faintness, and a sudden oppression about the chest ; he usually screams out or exclaims that he is dying, and continues moaning and whining. There is dyspnœa, purely cardiac in character, for the air enters the lungs freely ; this sense of dyspnœa is due to the arrest of the supply of blood to the lungs. The pulse becomes nearly imperceptible, though the heart's action is laboured and rapid ; the pupils are widely dilated. Death commonly results ; but not instantaneously, in many cases at least. Greene has collected 68 fatal cases of this accident : 24 died almost immediately, the rest at periods varying from three hours to seven days. Beauchesne's case lived a quarter of an hour after the occurrence of the accident ; Mirault's between three and four hours ; and Clemot's several hours. Amongst the other recorded fatal cases, I have not been able to find

any but vague statements as to the length of time during which the patients survived.

If the patient survive the immediate effects of the accident, he may probably recover without any bad symptoms, as happened in the case to which I have referred as occurring at the University College Hospital, and in an instance recorded by B. Cooper. In some of the cases that survived some days the fatal result is said to have been due to bronchitis or pneumonia, as happened to the patients of Roux and Malgaigne.

Cause.—The cause of the spontaneous entry of air into the veins has been very completely investigated and determined by the French Commission. If we open a large vein at the root of a dog's neck, near the thorax, in which the venous pulse, or flux and reflux of the blood, is perceptible, we shall see that air rushes in at each inspiration—but only at this time—never gaining entry during expiration. This is owing to the tendency to the formation of a vacuum within the thorax during inspiration. This suction action, or "venous inspiration," is confined to the large vessels in and near the thoracic cavity, being limited by the collapse of the coats of the veins at a little distance from this. If the veins were rigid tubes, it would extend throughout the body; but as they are not, it ceases where the coats collapse. It is indeed practically limited to that part of the root of the neck and the axilla where the venous flux and reflux are perceptible; and the space in which it occurs has been termed the "dangerous region." But, in certain circumstances, air may spontaneously gain admission at points beyond this.

It is well known that what is called by the French Surgeons the "canalization" of a vein, or its conversion into a rigid uncollapsing tube, is the condition which is most favourable to the introduction of air into it. Indeed, except in those situations in which there is a natural movement of flux and reflux of the blood in the veins, this accident cannot occur unless these vessels be canalized, or, in other words, prevented from collapsing, This canalization of the vessel may be occasioned in a variety of ways. Either the cut vein may be surrounded by indurated areolar tissue, which keeps it open like a hepatic vein; or the coats of the vessel may have acquired, as a consequence of inflammation, such a degree of thickness as to prevent their falling together when divided. Then, again, the principal veins at the root of the neck have, as Bérard has pointed out, such intimate connections with the neighbouring aponeurotic structures, that they are constantly kept in a state of tension, so that their sides are held apart when they are cut across. The contractions of the platysma and other muscles of the neck may likewise, as Sir C. Bell has shown, have a similar effect. In removing a tumour, also, that is situated about the neck, the traction exercised upon its pedicle may, if this contains a vein, cause it to become temporarily canalized; especially if the section be incomplete and in a transverse direction, when the wound will be rendered open and gaping by the retraction of the surrounding tissues. This patency of the incision in the vein is apt to be increased by the position that is necessarily given to the head and arm, in all operations of any magnitude about the shoulders and neck. Lastly, the introduction of air into a vein will be favoured by the vessel being divided in the angle of a wound, the vein being made open-mouthed and gaping when the flaps that form the angle are lifted up.

In all cases in which air has gained admittance into the veins during an

operation, these vessels were in one or other of the above-mentioned conditions. Thus, in Beauchesne's case, air was introduced in consequence of incomplete division of the external jugular, immediately above the right subclavian, whilst in a state of tension, during the removal of a portion of the clavicle. In a case that occurred to Dupuytren, a large vein connected with a tumour, and communicating with the jugular, was cut at the last stroke of the scalpel, whilst the tumour was being forcibly drawn up. The vein was found to be adherent to the sides of a sulcus, so that it remained gaping when cut. In a case related by Delpech, there was thickening of the coats of the axillary vein, causing it to gape like an artery. In Castara's case there was incomplete section of a vein, which opened into the subscapular, whilst the tumour was being raised up. In Roux's case a vein in the neck was opened, whilst a tumour, which was being removed from that region, was being forcibly raised in order to dissect under it. Ulrick saw the accident occur in consequence of the incomplete division of the internal jugular vein, which was implicated in a tumour in the neck. A similar case happened to Mirault of Angers, the internal jugular being divided to half its extent. A case occurred to Warren, in which the air entered by the subscapular vein, the coats of which were healthy, but in a state of tension in consequence of the position of the arm; and another, in which the same accident happened from the division of a small transverse branch of communication between the external and internal jugular, whilst in a state of tension. Mott, whilst removing a tumour of the parotid gland, opened the facial vein, which was in a state of tension in consequence of the position of the patient's head, when air was introduced. A case is related by Malgaigne in which this accident happened in consequence of the incomplete section of the external jugular vein, which was enveloped in a tumour that was being removed. Bégin also relates a case in which air entered in consequence of the puncture of the internal jugular vein whilst he was removing a tumour from the neck.

These cases, in which the condition of the wounded vein was particularized, show clearly what is the state of the vessel and of the surrounding parts that is most likely to favour the occurrence of the accident, and consequently what the Surgeon should particularly guard against in the removal of tumours about the neck and shoulders; viz., incomplete division of the veins, and the employment of forcible traction on the diseased mass at the moment of using the scalpel. In removing tumours from the neck and shoulder, it is in many cases impossible to avoid drawing them forcibly upwards or forwards, in order to get at their deeper attachments; but if this be necessary the chest should, for reasons that will immediately be pointed out, be tightly compressed, so that no deep inspirations may be made at the moment that the knife is being used, or before a divided or wounded vein can be effectually secured.

Preventive Treatment.—In the pre-anæsthetic days, the accidental entry of air into a vein during an operation was of more common occurrence than it is now. When a patient was under the knife, the respirations were generally shallow and restrained, the breath being held, whilst every now and then there was a deep gasping inspiration; at which moment, if a vein were opened in which the pulse was perceptible, or which was canalized, air was necessarily sucked in; and, as has already been said, in quantity and force proportioned to the depth of the inspiration. In these circumstances, the mode of guarding against the introduction of air into the veins was obvious. It was recom-

mended that the chest and abdomen should be so tightly bandaged with broad flannel rollers or laced napkins, as to prevent the deep gasping inspirations, and to keep the breathing as shallow as possible, consistently with the comfort of the patient. I have often found that the entrance of air into the veins of a dog could be arrested by forcibly compressing the chest of the animal, so as to limit the respiratory movements; but that, as soon as a deep inspiratory effort was made, the compression having been removed, a rush of air took place into the vessel. When such precautions were taken, therefore, during an operation about the root of the neck or summit of the thorax, and the chest was bandaged, as here recommended, the Surgeon had to be careful not to remove the compression until the operation was completed, and the wound dressed; for if this precaution was not attended to, the patient would, most probably, on the bandage being loosened, have made a deep inspiration, and air might have been sucked in at the very moment when all appeared safe. It is now rarely possible to adopt these precautionary measures, for the danger from applying such constriction during the administration of an anæsthetic would be greater than the risk of entrance of air, but I have retained a description of them partly on historic grounds and partly because circumstances might even now arise in which they might be necessary.

Curative Treatment.—Different plans have been recommended by Surgeons for the treatment of those cases in which air has already gained admittance into a vein; but, from the very fatal nature of this accident, it does not appear that much benefit has resulted from any of them: the recovery of the patient, in some of the cases, appearing to be due rather to the quantity of air that was introduced being insufficient to cause death, than to any effort on the part of the Surgeon. The two principal modes of treatment that have been recommended, are *suction of the air from the right auricle*, and the employment of *compression of the chest*. Thus Amussat and Blandin advise us to introduce the pipe of a syringe, a female catheter, or a flexible tube, into the wounded vein, if it be large enough to admit the instrument; and if not, to open the right jugular, and pass it down into the auricle, and then to employ suction, so as to empty the heart of the mixture of blood and air. At the same time that this is being done, we are, say they, to compress the chest as forcibly as possible, so as to squeeze more of the air out of the heart. Magendie and Rochoux advise suction alone; and Gerdy recommends us to be content with compression of the chest. Warren (of Boston) directs us to have recourse to *bleeding from the temporal artery*, to *tracheotomy*, or to *stimulants*, according to the condition of the patient.

The indications that present themselves in the treatment appear to me to be threefold:—

1. To keep up a due supply of blood to the brain.
2. To maintain the powers of the heart until the obstruction in the pulmonic capillaries can be overcome or removed.
3. To remove, if possible, the obstruction in the capillaries of the lungs.

We shall now see how far the means already mentioned, viz., suction, compression, &c., can fulfil these indications.

Suction would no doubt be highly advantageous if we could, by its means, remove the air that has gained access to the heart, and thus prevent the pulmonic capillaries from being still further obstructed. But putting

out of consideration the difficulty of finding the wounded vein; the still greater difficulty of introducing a suitable tube a sufficient distance into it; the danger of allowing the ingress of a fresh quantity of air, whilst opening the sides of the incision in the vein so as to introduce the tube; putting aside all these circumstances, which appear to me to be most serious objections, it becomes a question, according to Amussat, who was one of the strongest advocates of this mode of practice, whether, by suction with a syringe, or even by the mouth, any material quantity of air can be removed. He says that, even when the tube is introduced into the right auricle, much more blood than air is constantly withdrawn. These considerations, then, should, I think, make the Surgeon hesitate before having recourse to such a hazardous mode of procedure.

The next plan, that of *circular compression of the chest*, however valuable it may be in preventing the ingress of air, can, when it has once been introduced into the veins, have no effect in removing it from the circulatory system. We cannot, by any compression that we may employ, squeeze the air out of the heart. But compression may not only be productive of no positive good, but may even occasion much mischief, by embarrassing still further the already weakened respiratory movements, and thus interfering with the due aëration of the small quantity of blood that may yet be traversing the lungs.

Bleeding from the temporal artery can by no possibility be productive of any but an injurious effect, by diminishing the already too small quantity of blood in the arterial system. *Opening the right jugular vein* may, perhaps, to a certain extent, be serviceable, by unloading the right cavities of the heart, as John Reid has shown it to be capable of doing; and it has been recommended by Cormack on this account. Lastly, *tracheotomy* cannot be of the least service, as the arrest of the respiratory function is secondary, and not primary.

1. What, then, are the measures that a Surgeon should adopt in order to prevent the occurrence of a fatal termination in those cases in which air has been accidentally introduced into the veins during an operation? Beyond a doubt, the first thing to be done is to **prevent the further ingress of air,** by compressing the wounded vein with the finger, and, if practicable, securing it by a ligature. At all events, compression with the finger should never be omitted; as it has been shown by Nysten, Amussat, Magendie, and others, that it is only when the air that is introduced exceeds a certain quantity, that death ensues. All further entry of air having been thus prevented, our next object should be to **keep up a good supply of blood to the brain and nervous centres**, and thus maintain the integrity of their actions. The most efficient means of accomplishing this would probably be the plan recommended by Mercier; who, believing that death ensues in these cases, as in prolonged syncope, from a deficient supply of blood to the brain, recommends us to employ compression of the aorta and axillary arteries, so as to divert the whole of the blood that may pass through the lungs into the arterial system to the encephalon. This appears to me to be a very valuable piece of advice, and to be the most effectual way of carrying out the indication. The patient should, at the same time that the compression is being exercised on his axillary arteries and aorta, or, if it be preferred, as more convenient and easier than the last, on his femorals, be placed in a recumbent position as in ordinary fainting, so as to facilitate the afflux of blood to the head. The compression of the axillary and

femoral arteries may readily be made by the fingers of two of the assistants who are present at every operation of importance.

2. For the fulfilment of the second indication, that of **maintaining the action of the heart** until the obstruction in the capillaries of the lungs can be overcome or removed, artificial respiration should be resorted to as the most effectual means of keeping up the action of that organ. It seems also to help the circulation through the lungs, and thus to relieve the right side of the heart. For the purpose of keeping up artificial respiration, Silvester's method is the best. Before employing it, it will be necessary to remove everything that compresses the chest, or interferes in any way with the free exercise of the respiratory movements. Friction with the hand over the præcordial region, and the stimulus of ammonia to the nostrils, may at the same time be resorted to.

3. The third indication—that of **overcoming the obstruction in the pulmonic capillaries**—would probably be best fulfilled by the means adopted for the accomplishment of the second, viz., artificial respiration. That the action of respiration, if kept up sufficiently long, will enable the capillaries of the lungs to get rid of the air contained in them, appears to be a fact; for I have experimentally observed that, if a certain quantity of air be introduced into the jugular vein of a dog, and artificial respiration be then established, and maintained for half or three-quarters of an hour, a very small quantity indeed, if any, will be found, on killing the animal, in the cavities of the heart, or in the branches of the pulmonary vessels. I am aware that this is not altogether conclusive of the fact, as the air might be dissolved in the blood, or might still exist in the capillaries of the lungs, although none might be found in the larger branches of the pulmonary artery; but still it seems to me that we can hardly account for the large quantity of air that will disappear when artificial respiration is kept up, in any other way than that some, if not all of it, passes out of the capillary vessels into the air cells of the lungs.

CHAPTER XVIII.

SPECIAL INJURIES OF NERVES, MUSCLES, AND TENDONS.

INJURIES OF NERVES.

Contusion.—Nerves are often contused; the injury producing a tingling sensation at their extremities, and pain at the part struck. These effects usually pass off in the course of a few minutes or hours. If the blow have been sufficiently severe to cause hæmorrhage amongst the fibres of the nerve, the symptoms may be more severe and persistent, and temporary paralysis of the parts supplied by the injured nerve may result. In certain conditions of the system, more especially in hysterical women, the symptoms may last for a considerable period, even after slight contusions, and may give rise to neuralgia of a very permanent character. In other cases the continuance of the symptoms appears to be due to the supervention of chronic neuritis, accompanied by thickening of the neurilemma, causing compression of the nerve-fibres, and thus producing more or less extensive paralysis, accompanied by neuralgic pain in the part supplied by the affected nerve.

Strains.—Any violent movement, which stretches a nerve forcibly, may occasionally be slowly followed by the symptoms of chronic neuritis to be described later on. This is most common in the nerves of the brachial plexus in the axilla.

Compression.—This most commonly arises from disease, as from the pressure of tumours or aneurisms, but it may be the result of injury; thus, the brachial plexus may be pressed on by the head of the humerus in a dislocation, the spinal nerves may be compressed at the intervertebral foramina in cases of fracture of the spine, and the fragments of bone in a fracture of a limb may press on contiguous nerves. Another common form of compression is the so-called crutch-palsy, resulting from the pressure of the upper end of the crutch upon the nerves of the brachial plexus; and a similar paralysis of the muscles of the front of the leg is not uncommonly met with, as the result of pressure on the external popliteal nerve as it winds round the head of the fibula, from splints applied without sufficient padding. Nerves may be compressed also by the growth of callus from a fractured bone, or by the contraction of the cicatricial tissue of a scar. The mildest effects of pressure are the numbness, tingling, and sense of weakness with which everyone is familiar, as a consequence of pressure on the ulnar nerve from sleeping with the arm under the head. The effects of pressure are proportional to its severity and duration. If it lasts for a sufficient length of time, complete loss of sensation and paralysis are produced in the parts supplied by the nerve pressed upon, followed by wasting and degeneration of the muscles. Such cases usually recover in time, if the cause be removed and the limb be afterwards treated by the methods described later on.

Rupture or Laceration.—Healthy nerves are never torn across except in

the most severe injuries, such as compound dislocations and severe compound fractures. When paralysis and loss of sensation follow a severe subcutaneous injury, it is due to contusion, and possibly to rupture of some of the fibres, but the continuity of the nerve is never completely interrupted.

Puncture.—If a nerve be punctured, unpleasant consequences sometimes result, more especially in delicate women. Not only does it happen, in such subjects, that the part below the puncture becomes the seat of various tingling, shooting, and burning pains, but the neuralgic condition appears to travel upwards along the proximal part of the nervous trunk. Thus, I have more than once seen a puncture of one of the digital branches of the ulnar nerve produce a kind of painful paralysis of its trunk, rendering the arm nearly useless. I have seen the same effects occur in the median nerve, from so slight a cause as the puncture of the finger by a needle. It occasionally happens in venesection at the bend of the arm, that a branch of the internal cutaneous nerve is pricked with the lancet, and that very persistent neuralgia occurs in consequence.

Division.—**Primary Effects.**—When a nerve is completely cut across, or its conducting power in any way abolished, whether by contusion, compression, or laceration, prolonged paralysis of sensation or motion, or both, according as the nerve is sensory, motor, or compound, occurs in all the parts supplied by it. Consequently, if the integrity of the nerve be essential to life, as is that of the pneumogastric, death must ensue. When the nerve is partially divided, or bruised as well as severed, as in cases of gun-shot-injury, neuralgia in the parts supplied by it beyond, and sometimes also in those above, the injury, is associated with the paralytic symptoms. The patient complains of numbness or deadness in the parts supplied by it, and all tactile sensibility is lost; but various anomalous painful sensations of a burning, tickling, tingling, or creeping kind are complained of. These sensations often give the idea of increased heat of the part to the patient, and are compared by him to the effect that would be produced by molten lead or boiling water running through it. But the sensation of heat is deceptive, for the part will be found on examination to be actually colder than natural.

The **Secondary Effects** of division of a nerve differ according to the nature of the nerve divided. The section of a purely motor nerve, such as the facial, causes complete paralysis, with subsequent wasting and degeneration of the muscles supplied by it, but the nutrition of the superficial structures is not affected. The division of a purely sensory nerve, such as the fifth, completely abolishes sensation in the area it supplies, but does not necessarily cause any serious disturbance of nutrition, although, from the loss of sensibility, the part is more exposed to suffer from injuries than a healthy one. Arloing and Tripier have shown by experiment that in the case of the division of a superficial sensory nerve, the neighbouring cutaneous nerves which communicate with the terminal branches of that divided, rapidly assume its functions, so that sensibility may return in a few days without repair of the divided nerve. After the division of a compound nerve, the nutrition of the part supplied by it is seriously modified. It becomes congested, bluish, and colder than natural. This fall of temperature is often very marked. Thus, I found in a woman who was under my care for a wound of the fore-arm, by which the ulnar nerve had been divided, that, twenty-one days after the injury, the temperature between the ring and the little finger of the injured side was

9° Fahr. below that of the same spot in the opposite hand. Sometimes the part becomes œdematous; the skin often becomes rough, and peels; or in other cases, it is smooth, red, and shining, the nails grow badly, and are brittle or scaly. Chilblains readily form from slight exposure to cold, and they frequently become vesicular or slough, leaving sluggish and unhealthy ulcers. Wounds in such parts heal badly, and are peculiarly prone to be affected by unhealthy spreading inflammations. If the patient be a growing child, the development of the affected part will be more or less completely arrested.

The changes in the muscles in these cases are of great importance. From the moment the nerve is divided, all voluntary power is of course lost. Experiments have shown that up to the fourth day in mammals, stimulation of the lower end of the divided nerve will cause contraction of the muscles. For about the same time in the human subject it will be found that the muscles respond more readily than natural to the Faradic current, but after this the irritability of the muscles to the current becomes gradually less, while at the same time they waste distinctly. At the end of some weeks, the muscles cease entirely to respond to Faradism. With the continuous current slowly interrupted, the course of events is as follows: first, the muscle responds too readily for a few days, after which the irritability of the muscle gradually diminishes until it disappears entirely. This takes place, however, very slowly, the muscle frequently continuing to respond to the continuous current, slowly interrupted, for many months after the Faradic current has ceased to act. These reactions are most useful guides in diagnosis, prognosis, and treatment. As the muscles become flabby and wasted, deformities of various kinds may ensue, from the disturbance of the proper balance of antagonism between the different sets of muscles of the limb.

If union takes place between the opposite ends of the divided nerve, the various phenomena that have just been described gradually subside, and complete restoration, first of sensation and afterwards of motion, with a return to the normal nutrition of the part, eventually takes place. In many cases, however, especially if a piece of the nerve have been removed, or if the wound in which it has been divided heal by the second intention, recovery fails to take place. Sometimes, under these circumstances, the nerve at the seat of its division becomes implicated in a mass of dense cicatricial tissue, and its central end becomes bulbous, just as in similar conditions in stumps, and it may then become the seat and the source of the most intense sufferings—neuralgic pains darting like electric shocks downwards to the terminal branches and upwards along the trunk of the affected nerve.

Pathology.—If a nerve be completely divided its two ends retract very slightly, not more than a sixteenth of an inch. In cases that have been examined at a later period, the separation has been found to have increased to about a third or half an inch, or even more. Degeneration sets in in the peripheral end about four days after it has been cut off from its communication with the nerve centres. The medullary sheaths undergo fatty degeneration, and more or less completely disappear by about the end of a month. In the central end degeneration does not set in for a much longer period. When regeneration of the nerve takes place all observers are agreed that the first step is the formation of a bond of union between the two ends composed of a delicate spindle-cell tissue, which connects the neurilemma of the upper end with that of the lower. By what process the new nerve-fibres are developed in this

mass of young connective tissue is still doubtful, but most observers are of the opinion that they are formed by a growth proceeding from the axis-cylinder of the central end. After the bond of union is complete before the nerve can fully resume its functions, the peripheral end—which has, as before stated, undergone a certain degree of degeneration—must also be regenerated. This process proceeds slowly down the nerve from the injured spot. The restoration of a contused or divided nerve is always a slow process, and is frequently not complete for from three months to a year.

The question whether nerves can heal by the first intention, has been much debated of late years. If the term be used in the sense of complete restoration of the function of the nerve in a few days, there is no evidence to show that it can take place. On the other hand the two ends can doubtless be united by young connective tissue at a very early period, and the more closely the ends can be kept in apposition, the more rapidly will the fibres of the central end communicate with those of the peripheral. About a month is, perhaps, the earliest time at which motor power will return after division of a nerve.

Treatment of Injuries causing Interruption of the Conducting Power of a Nerve.—The treatment of these injuries may be divided into two parts. 1st, the *Local treatment* of the injured nerve, and 2nd, the treatment of the *Paralysed part*.

The **Local Treatment.**—In cases of *subcutaneous injury* nothing can be done. It may be taken for granted that although the nerve may be completely paralysed, its continuity is not destroyed by any subcutaneous injury. On dissecting limbs amputated for the most severe railway- or machinery-accidents, the nerves are almost invariably found untorn in the midst of the crushed tissues. To cut down, therefore, in a subcutaneous injury with the intention of suturing the nerve would be a grievous error. When the function of the nerve is abolished by *pressure*, the cause of pressure must be removed if possible, as by the cure of an aneurism, the excision of a tumour, or the reduction of a dislocation. When the cause of the paralysis is the *implication of the nerve in a cicatrix or in the callus of a fracture*, nothing should be done locally until, after waiting many months, it becomes evident that nature will not effect a cure. It will be very rarely found necessary in such cases to adopt any operative plan of treatment, the symptoms disappearing as the scar becomes looser with age, or as the provisional callus of the fracture is absorbed. Warren, however, relieved a case of neuralgia resulting from implication and compression of a nerve by condensed cicatricial tissue by dissecting it out of the midst of this without dividing or otherwise injuring it.

In cases of *division of a nerve in an open wound* no doubt exists as to the proper line of treatment—the two ends of the nerve should be found and carefully secured to each other by fine sutures. The best material for suture is chromic catgut, as it is desired to keep the ends in contact only for a few days while the young connective tissue which forms the preliminary bond of union is being developed. Silk, which would not be absorbed for many weeks, would be very likely to cause some irritation and possibly severe neuralgia. The needle should be either a common darning needle, which, if necessary, can easily be bent into a curve in the flame of a spirit-lamp and hardened again by being dipped in cold water; the ordinary flat surgical needle, with its cutting edges, needlessly damages the fibres of the nerve. Three or four sutures having been applied, according to the size of the nerve, the wound must be closed and treated

by some antiseptic method if possible; union by the second intention being fatal to success. The limb must be put in such a position as completely to relax any strain on the nerve. In about half the cases treated in this way good union will be obtained with restoration of function. If the first attempt fail from suppuration in the wound, another attempt may be made later on as a secondary operation. Lastly, if the nerve have been divided, the wound long healed, and no repair have taken place, a secondary operation may be performed with a hope of success even at a very remote period after the injury. Such operations would, however, be probably useless if the muscles supplied by the affected nerve failed to respond to the continuous current slowly interrupted. The operation is performed by exposing the nerve freely. Its central extremity will usually be found by its bulbous condition, which can readily be felt; the lower end is often atrophied and more difficult to find. The ends of the nerve may then be pared, so as to remove the dense scar-tissue with which they are covered, but no more should be taken away than is absolutely necessary. After this they are sutured as in a fresh wound. This operation has been successfully performed by Jessop in a case of wound of the ulnar nerve which had happened some years before. Wheelhouse, in 1875, cut down upon the sciatic nerve in a case in which it had been wounded by a scythe nine months previously. The limb was completely paralysed and useless; the muscles were much wasted and their electrical irritability almost lost; the ends were two inches apart, the upper large and bulbous, and the lower slightly atrophied. The bulb was removed from the central end, and both ends pared till healthy nerve-tissue appeared, and then brought together with fine catgut sutures. It was only by flexing the knee forcibly that the ends could be got into sufficiently close apposition to allow of the sutures being tied. Sensation returned in about a month, and then the leg was gradually straightened. The sensibility remained unimpaired and motion returned soon after. At the end of three months the patient could walk with the aid of a stick; and two years afterwards, although the limb had not regained its full size, he could work in the fields and walk without artificial help.

2. **Treatment of the Paralysed Limb.**—In all those cases in which the nerve is not completely divided, treatment of the paralysed parts is alone possible, the object being to prevent wasting and to maintain the nutrition of the limb in such a way that, when restoration of the nerve takes place, the muscles shall be in a state to respond to the influence of the will. Moreover, much can be done by judicious treatment to maintain the temperature, to avoid the formation of chilblains or other sores, to prevent the development of deformities, and in children or young subjects to keep up the growth. In order to keep up the nutrition and to overcome the congestion which is always met with in the paralysed part, it must be made of a healthy red colour at least twice a-day. There is no more efficient means of doing this than by the use of the continuous electric current. The sponge-holder connected with the positive pole of the battery may be applied over the course of the nerves, while the limb is freely sponged with the other. At the same time each separate muscle should, if possible, be made to contract by slow interruptions of the current. In a minute or more the whole paralysed part will become bright red. In the absence of the battery, much may be done by properly applied rubbing or massage. The part should be carefully protected

by warm clothing, and the patient should be encouraged to use it as much as possible. If only a single group of muscles is paralysed, properly designed apparatus may be required to overcome the deformity which ensues, but this should never be used if it can be avoided, as it interferes to some extent with the use of the limb.

TRAUMATIC NEURITIS.—This disease may follow almost any injury of a nerve. It is most common in civil practice as the result of bruises or strains, and is sometimes connected with gout or rheumatism. In wounds it seldom arises unless union has taken place by the second intention with unhealthy inflammation and suppuration; and, consequently, it is a rare affection in amputation-stumps. In gun-shot-wounds, in which the nerves are often contused and partially divided and in which the wound almost always heals with suppuration, it is more common.

Pathology.—The disease consists essentially of a chronic inflammation slowly ascending the nerve, with thickening of the neurilemma and overgrowth of the interfascicular areolar tissue. The accompanying drawing

Fig. 169.—Section from Lower Cord of Brachial Plexus near Intervertebral Foramina, showing the lesions of Chronic Neuritis.
a. Secondary fasciculi, showing atrophied fibres (circles not much larger under 300 diam. than those of normal nerve under 65 diam.); very few axis-cylinders present. Tissue between fibres increased.
a'. Small aggregation of fibres, separated from others by dense inter-fibrillar connective tissue.
b. Immensely hypertrophied inter-fascicular areolar tissue. Sheaths of fasciculi no longer distinct.
c. Dilated blood-vessels surrounded by altered connective tissue.
d. Yellow granular pigment lying in areolar tissue, mostly in neighbourhood of vessels (Sands and Seguin).

(Fig. 169), from a case in which Drs. Sands and Seguin, of New York, excised the cords which go to form the brachial plexus, close to the intervertebral foramina, illustrates well this compression of the nervous structures by dense masses of interfascicular areolar tissue greatly hypertrophied, and permeated by dilated blood-vessels. In extreme cases the disease is said to extend to the cord, and give rise to sclerosis of the cord.

Symptoms.—The symptoms of traumatic neuritis are intense pain and tenderness in the line of the affected nerve. Sensation is variously modified in the parts supplied by the nerve; there may be numbness, or tingling, or anæsthesia; in other cases there may be intense neuralgic pain. Occasionally there are spasms, but more commonly there is weakness or paralysis of some of the muscles supplied. Poore has shown that in a considerable proportion of the cases which have come under his care for loss of writing-power, tenderness has been found in the course of some one or more of the nerves of the arm, and on tracing the history, the origin of the affection was frequently found to be a strain or other injury. In another case recorded by him, the whole brachial plexus in the axilla became intensely tender after a violent strain of the shoulder. The patient's sufferings were very great, and nothing gave him much relief. At last, after prolonged rest, the symptoms subsided, and it was then found that the serratus magnus was paralysed. Finally, this also recovered. In hysterical patients the symptoms are often greatly exaggerated.

Treatment.—In the early and painful stage of the disease, electricity does no good, in fact it may aggravate the mischief. The tender nerves should be freely blistered, and the affected limb put at perfect rest. If any constitutional condition as gout, rheumatism, or syphilis can be found, it must be treated by appropriate means. These cases are always chronic, often lasting many months before the symptoms disappear. In others, all milder means having failed, surgical operations of various kinds have been undertaken for the relief of the patient. These operations are of three kinds:—1. Excision of the bulbous ends of the nerves in cases of neuritis following amputation; 2. Division or excision of a portion of the affected nerve; and 3. Nerve-stretching.

1. **Excision of the Bulbous Ends of the Nerves.**—This has been undertaken usually under the impression that the bulbous end was the seat of the mischief. In some cases no doubt a painful stump is due to implication of the end of the nerve in the cicatrix, and then relief is given by the operation. If the symptoms are however due to true chronic ascending neuritis, this operation, although occasionally giving relief for a short time, is never productive of a cure.

2. **Division or excision of portions of the Nerve.**—The smaller nerves of the limbs have been repeatedly divided or partially excised, in cases of persistent traumatic neuralgia. The larger nervous trunks, such as the median, musculo-spiral, and ulnar, have been treated in the same way in the upper; and the external popliteal, and even the sciatic nerve in the lower limb, has been partially excised as a last resource in extreme cases. These operations have in some cases effected a permanent cure, in others they have been followed by temporary relief only.

It was reserved for Sands, of New York, to remove a section of the whole brachial plexus close to the exit of the nerves from the spinal column. This was done in a lad aged eighteen, whose right arm had been seriously injured in firing a salute. The arm was amputated, but the patient suffered the most agonizing torture from chronic nerve-lesion high up in the limb. So great were his sufferings that he became uncontrollable in his actions, and, though perfectly sane, gave way to fits of the most intense excitement. The operation consisted in making an incision along the outer border of the right

sterno-mastoid, and a transverse one following the line of the clavicle. The ⅃-shaped flap was turned up, the carotid sheath and its contents carried to one side, and the brachial plexus exposed. Pieces fully a quarter of an inch in length were cut out from the four lower cervical and first dorsal nerves, and from one of these Fig. 169 was taken. Considerable improvement, though not complete relief from suffering, followed the operation.

3. **Nerve-stretching.**—The operation of nerve-stretching was introduced by Nussbaum originally as a mode of treating intense neuralgia following injury. In a case of this kind affecting the arm, and resulting from gun-shot injury, he cut down and stretched the ulnar nerve, then the nerves surrounding the brachial artery, and lastly, the brachial plexus, itself pulling vigorously on the nervous cords. The result was a perfect cure. Since then the operation has been performed on nerves in all parts of the body and for a great variety of diseases, but it will be perhaps most conveniently described here.

Under the name of nerve-stretching two distinct operations are included. In operating on the larger trunks the nerve is exposed, cleanly isolated for an inch or more, and forcibly stretched either by passing the finger beneath it, as in the case of the sciatic, or by means of a hook; but on account of the great size and strength of the nerve its power of conduction is never completely destroyed, even if considerable force be used, although there may be some modification in its function. In operation on the smaller nerves, as the facial, the nerve is exposed and stretched with a hook, and it will always be found, if moderate force be used, that conducting power is as completely abolished as if the nerve had been divided. This operation is therefore equivalent to division, the only difference being that, as the continuity of the nerve is not destroyed, restoration of function is certain to take place sooner or later. In the former case the mode of action is doubtful; but it has been suggested that it acts by breaking down adhesions which have been formed amongst the fibres of the nerve and between them and surrounding parts during a past attack of neuritis. In the latter case, the period of rest given by temporary interruption of the function of the nerve may relieve the disease for which the operation is undertaken.

Since Nussbaum's operation, nerve-stretching has been frequently repeated with very variable results. Amongst the earliest cases in London was one in which Callender successfully stretched the median. At University College Hospital, Marcus Beck stretched the cords of the brachial plexus above the clavicle in a case of intense neuralgia and spasm of the stump after amputation at the shoulder-joint. The bulbous extremities of the nerves had been twice before excised from the axilla. This case was probably one of genuine chronic neuritis, possibly extending even to the cord, and the operation completely failed to give any relief. Nerve-stretching, however, being devoid of danger and certain not to make the patient worse, may be adopted without hesitation in all cases in which there is a possible chance of its giving relief.

INJURIES OF MUSCLES AND TENDONS.

Contusions.—Muscles are frequently bruised by violent blows or falls, a few fibres being often ruptured. The chief signs of this injury are a sense of inability to use the muscles and great pain on attempting to do so. There is tenderness on pressure over the bruised spot, but passive movements do not

cause pain so long as they do not put the injured fibres on the stretch. By careful attention to these points, it is easy to distinguish these injuries from fractures of neighbouring bones which they sometimes resemble—especially in the neighbourhood of the shoulder-joint.

Sprains or Strains of muscular parts, without rupture of fibres, are of very common occurrence, especially about the shoulders, hip, and loins, and are accompanied by much pain, stiffness, and inability to move the part. When they occur in rheumatic subjects, these injuries not uncommonly give rise to severe and persistent symptoms; painful atrophy, rigidity, or local paralysis of the injured muscle being in some cases induced. It is then often difficult to determine how much is due to the direct strain of the muscle, and how much to chronic neuritis resulting from a simultaneous strain of the nerves. When complete atrophy of a muscle preceded by much pain follows a strain, it is probable that the nerves have been implicated in the injury.

In the **Treatment** of these accidents, when recent, it will be found that kneading or rubbing the part with a stimulating embrocation gives relief, but, if the pain be severe, the application of hot fomentations with rest is more efficient. In the later stages, blisters applied to the points at which the pain is most severely felt are often beneficial. If the injury occur in persons of a rheumatic constitution, the effects are much more severe and persistent than in those who are otherwise constituted. In such persons, douches, frictions, and passive motion will, after a time, be necessary, together with proper constitutional treatment. In strumous subjects, a sprain may lead to the development of very serious articular inflammation.

Muscles that have been sprained sometimes undergo a species of rigid atrophy, with much impairment of motion of the limb or joint. In such cases, frictions, douches, and above all, electricity, will be found useful.

Rupture of the Sheath.—It occasionally happens that the muscular sheath is ruptured, so that the belly of the muscle forms a kind of hernial protrusion through the aperture; or the tendon may be displaced by rupture of its sheath. This usually happens with the biceps, or the extensors of the fingers or rectus femoris.

Dislocation or Displacement of Muscles and Tendons.—The long slender muscles of the forearm, and the complicated muscles of the back with their innumerable interdigitating tendons and bellies, and all tendons lying in grooves in bones are liable to be displaced by some sudden and unusual movement. The accident is popularly spoken of as a "rick." The characteristic features of the accident are, that during some forcible movement the patient feels a sudden severe pain, localized to a single spot, and at the same time he finds himself unable to execute certain movements. The Surgeon in the majority of cases by careful examination and by finding out exactly what movement causes the pain, will be able to ascertain which is the affected muscle. In the case of the slipping out of a superficial tendon, the displaced part may be felt moving in its abnormal situation. Callender laid down the following rules for the treatment of this injury. First, guided by the pain, decide as to the muscle, or digitation of a muscle, probably the seat of the injury. Secondly, relax the muscle as far as possible by putting the part in the position which would be induced by its full contraction. Thirdly, by firm manipulation, such as by rubbing with the hand, or by kneading with the thumb, endeavour to replace it. Fourthly, if this fail, make pressure over the

part whilst you make the patient contract the muscle, or if he cannot do this, put the part suddenly in such a position as to stretch the muscle. These manipulations must be done without an anæsthetic, as we need guidance from the sensations of the patient and action of the affected muscle. Replacement is seldom possible after two or three weeks. If the condition is left unrelieved the parts seem to accommodate themselves to their new positions, and the pain subsides, but some permanent weakness may remain. The accident is always likely to recur, even if the displacement has been successfully reduced.

The following are the chief situations in which this accident has been met with.

The *Long Tendon of the Biceps.* Callender described a case of this accident. There was great pain and inability to move the biceps or even the shoulder-joint. The shoulder seemed to droop forwards. The tendon could be felt lying at the inner side of its groove. It could be replaced, but no treatment would keep it there.

Various *Tendons at the Wrist* have been displaced. They are usually replaced without difficulty by the means above described. The parts must be kept fixed for about two weeks, by means of splints and properly arranged pads.

The *Small Muscles of the Back,* or of the back of the neck, are occasionally displaced. Replacement can best be effected by firm pressure over the painful spot, while the patient carries out the movement that gives him pain.

The *Tendon of the Peroneus Longus* may slip out of its sheath behind the outer ankle, the sheath being torn in some violent twist of the foot inwards. The accident is liable to recur, and is often a source of much discomfort and temporary lameness. The treatment consists in the first instance of absolute fixity of the foot for some weeks in plaster bandages or splints, to give time for the sheath to consolidate. To prevent recurrence, a spring clip should be worn, so as to press the tendon against the fibula.

Rupture and Division.—Subcutaneous rupture of muscles and tendons not unfrequently occurs, not so much from any external violence, as from the contraction of the muscle rupturing its own substance. The rupture may occur at one of four points: in the muscular substance itself; at the line of junction between the muscle and tendon; through the tendon; and, lastly, at the point of insertion of the muscle or tendon into bone. Sédillot found that, in 21 cases, the rupture occurred at the point of origin of the tendon from the muscle 13 times; and in the remaining 8, the muscle itself was torn.

These ruptures occur most commonly in middle-aged or elderly men, who have lost the elasticity of youth, though their physical strength is unimpaired. At the moment of rupture, the patient usually experiences a sudden shock, as if he had received a blow, and sometimes hears a snap. He becomes unable to use the injured limb, and at the part where the rupture has occurred he finds a hollow or pit, produced by the retraction of the ends of the torn muscle, the belly of which contracts into a hard lump.

These accidents, though troublesome, are seldom serious. The tendo Achillis, the quadriceps extensor of the thigh, the triceps of the arm, the biceps, the deltoid, the rectus abdominis, are the tendons and muscles that most commonly give way, with the relative frequency of the order in which they are placed.

Muscles and tendons may be cut across accidentally or purposely in almost

any part of the body. In these injuries there is always a considerable amount of gaping of the wound, owing to the retraction of both ends, if a muscle be divided, and of the muscular end only, if a muscle be separated from its tendon or the tendon cut across.

Union.—The mode of union of these injuries has been well described by Paget. When a tendon is cut across, the space between the ends is immediately filled by a blood clot. Exudation rapidly follows from the vascular sheath and areolar tissue in the neighbourhood, the clot is penetrated by the wandering cells, and is soon decolourized and absorbed, till on the third day its place is occupied by a soft greyish-pink mass, extending also into the sheath and surrounding the cut ends of the tendon. This mass will be found to be composed of small round cells, with a homogeneous intercellular substance, mixed with which may be here and there seen some remains of the blood-clot. New vessels penetrate it from without, and it afterwards undergoes the ordinary changes observed in the development of granulation-tissue into fibrous-tissue. By experiments upon animals, Paget showed that by about the fourth or fifth day the bond of union has become more defined in outline, and forms a distinct cord-like mass between the ends of the tendon, and the microscope shows that the cells have lengthened out and become spindle-shaped, so that the tissue appears fibrillated; in the course of two or three more days, it becomes tough and filamentous; after this the tissue gradually perfects itself, until it closely resembles tendinous structure, though for some time it remains dull white and more cicatricial in appearance. The strength of this bond of union is marvellously great; Paget found that the tendo Achillis of a rabbit, six days after its division, required a weight of 20 lbs. to rupture it. In ten days the breaking weight was 56 lbs. Divided muscles unite in the same way as tendons, but less quickly, and by fibrous cicatricial bonds; Weber, Gussenbauer and others have, however, recorded observations which tend to show that under favourable conditions, gradual regeneration of muscular tissue may take place in the scar.

Treatment.—The principle of treatment in these cases when the injury is subcutaneous is extremely simple: it consists in relaxing the muscles by position, so as to approximate the divided ends; and in maintaining the limb in this position for a sufficient length of time for proper union to take place. If muscular relaxation be not attended to, the uniting bond will be elongated and weak, and perhaps altogether inefficient. Stiffness and weakness are often left for a length of time—for many months, indeed—after union has taken place; very commonly, owing to the adhesion of the divided tendon to its sheath, and of this to the neighbouring soft structures. Warm sea-water-douches, followed by methodical friction, will greatly tend to restore the suppleness of the parts. If the stiffness does not readily yield to milder treatment, the adhesions must be broken down by forcible movement of the part under an anæsthetic. By the end of one month after the injury, there will be no fear of tearing through the bond of union while so doing.

Tendons or muscles divided in an open wound must be treated by immediate suture. Either chromic catgut or antiseptic silk sutures may be used, the former being preferable; the wound should be closed over them, the limb placed in such a position as to relax the tendon, and every effort made to obtain union by the first intention. If suppuration takes place between the ends of a divided tendon, the bond of union, if any is developed, is almost

always imperfect, and the divided ends form the most hopelessly firm adhesions to the surrounding parts. Should septic pus form in the wound, there is great risk of its burrowing widely in the sheath, or in the loose areolar tissue surrounding the divided tendon, an accident which may be followed by sloughing of the tendon, or which, if that be avoided, must necessarily lead to the formation of extensive and dense adhesions.

Injuries of Special Muscles and Tendons.—When the **tendo Achillis** is ruptured, the best mode of treatment consists in the application of an apparatus formed of a dog-collar placed round the thigh above the knee, from which a cord is attached to a loop in the back of a slipper; by shortening this cord, the leg is bent on the thigh, and the foot extended, so that the muscles of the calf become completely relaxed (Fig. 170). After this simple apparatus has been used for two or three weeks the patient may be allowed to go about, wearing a high-heeled shoe for some weeks longer.

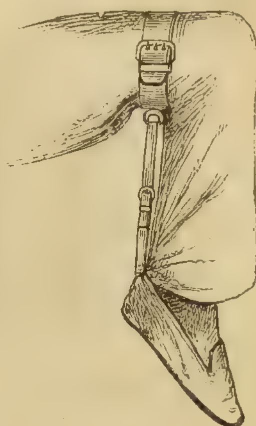


Fig. 170.—Strap for Rupture of the tendo Achillis.

The **Quadriceps Extensor of the Thigh** may be torn away from the insertion into the patella, or the tendon of the rectus may be ruptured about an inch above this. Such an accident occurs in the same way that a patella is broken across, namely, by a violent muscular effort to prevent falling whilst the knee is semi-flexed. Under these circumstances one of three things will happen; the tendon of the rectus, the patella, or the ligamentum patellæ, will give way. More commonly the patella is broken across; next the tendon gives way, and less frequently the ligament. When the tendon gives way the signs are unmistakeable. The patient falls on the ground, is unable to raise or stand on the injured limb, and a distinct gap occasioned by the retraction of the muscle can be felt above the patella between the fleshy masses of the vasti, which are very rarely torn. The accident is usually followed by some swelling of the joint. Owing to the great distance to which the upper end of the torn tendon is retracted, union may fail to take place, but even if this does occur, the attachments of the vasti remaining intact, the patient suffers but little inconvenience.

The Ligamentum Patellæ is rarely ruptured. When it has given way the patella is drawn up and a deep gap is left below it.

The **Treatment** both of rupture of the tendon and of the ligament is the same as that of fractured patella, viz., elevation of the limb, supported on a back splint in the extended position at an angle of about 135° with the body. This must be continued for several weeks, when the patient may be allowed to get about with the joint protected by a knee-cap. In three or four cases of this accident which I have seen, somewhat troublesome stiffness of the parts has long been left.

In **Rupture of the Muscles or Tendons of the Arms or Shoulder** support in a sling is all the special treatment needed. When the muscles about the shoulder are the seat of injury, rapid atrophy is apt to ensue, probably owing to the implication of the circumflex and suprascapular nerves, and consequent interference with the nutrition of the part. Fig. 171 is a good illustration of the remote effects of such a strain of the capsular muscles

of the shoulder-joint. In this case the accident arose from severe dragging upon the arm by the reins of a runaway horse.

In division of the **Extensor Tendons of the Fingers**—a very common accident—the tendons should, if possible, be sutured, and the hand must be kept extended on a straight splint for three weeks, until perfect union has taken place.

Fig. 171.—Atrophy of Capsular Muscles of Shoulder.

The **Flexor Tendons** of the fingers may also be divided. In these cases the phalanges cannot be bent, the fingers stretching out straight. The only treatment consists in flexing the finger fully into the palm of the hand, where it must be retained by strips of plaster.

Laceration of the Rectus Abdominis Muscle may occur in the efforts of childbirth, or from blows upon the abdominal wall; a ventral hernia being the consequence. Guthrie relates several remarkable cases occurring in military practice, of progressive atrophy of a part of the muscular wall of the abdomen following blows.

Rider's Sprain may occur in two situations—in the adductors, and in the internal rotators of the femur. It is more commonly met with in the adductors. It consists in a laceration of some of the muscular fibres or of the fascia covering the muscles. It is due to a violent or spasmodic contraction of these muscles when the rider is in danger of losing his seat. The pain is very great. The grip is lost, and the sufferer is unable to ride. When the internal rotators, or some of the capsular muscles of the hip-joint are the seats of the sprain, the pain and disability are referred to the back of the trochanter.

The Treatment consists in rest, and the use of a spica strap or bandage, with a pad over the injured muscle, so as to compress it and control its action.

CHAPTER XIX.

INJURIES OF BONES AND JOINTS.

INJURIES OF BONES.

A BONE may be bruised, bent, cut, or fractured.

Bruising of the Bone and Periosteum often occurs, and is usually of no great moment. A moderate contusion, however, of a bone that is but thinly covered, as the shin or elbow, may give rise to troublesome symptoms from inflammation of the periosteum. If the contusion be severe, the vitality of a layer, or even of the whole substance of the bone, may be destroyed, as happens sometimes from the graze or contusion of a bullet; or the bone may become deeply inflamed, and suppuration take place in its cancellous structure. In old people, the contusion of a bone is frequently followed by atrophy and shortening, as happens in the neck of the femur; in strumous constitutions, it may lead to serious disease of the bone, ending in its complete disorganization.

In the *Treatment* of bruised bone, immediate relief may be afforded by leeches, fomentations, or the application of warm lead and opium lotion. At a later period, and more especially if the pain be severe at night, iodide of potassium may be useful. There is a very troublesome condition following a graze of the shin, with bruise of the periosteum and tibia, in which the slight abrasion does not heal readily, and the periosteum becomes thickened and pulpy. In these cases, rest of the limb, the application of lead lotion, the support of a bandage, and the administration of the iodide with bark will be found to afford great relief. The consequences of bruise will be considered when we come to speak of necrosis.

Bending of Bone may occur in two conditions, viz.: without or with fracture. Bending without fracture is most commonly met with in very young subjects, before the completion of ossification; the bone being healthy, but naturally soft, at this period of life. It occasionally takes place in adult life, but is then the result of some structural change, by which the natural firmness of the osseous tissue is diminished. The bending most commonly occurs in the long or slender bones, especially the clavicle, the radius, and the femur, but sometimes is met with in the flat bones, or those of the skull, in which depression takes place from a blow without fracture having occurred. In many cases of bending both of long and of flat bones, there is partial fracture on the convex side—the "green-stick fracture" (see page 500).

The *Treatment* is simple: the Surgeon gradually straightens the bone, by applying a splint on its concave side, towards which the bone is pressed by a bandage and a pad applied upon its greatest convexity.

Fractures will be described in the following two chapters.

INJURIES OF JOINTS.

Contusions.—Joints are often *contused* by kicks, falls, or blows, so as to be severely injured, with much pain, and consecutive inflammation of the capsule, synovial membrane, or other structures entering into their formation. As a result of contusion the joint may be suddenly distended with blood, *hæmarthrosis*. The blood so effused, mixed as it always is with much synovia, slowly undergoes absorption, without leading to any inconvenience.

The **Treatment** should consist of complete rest of the part with the application of a splint. An evaporating lotion or an ice-bag may be applied over the joint. Should the amount of effusion be very considerable the tension of the joint and the consequent pain may be at once relieved by removing the effused blood by means of the aspirator. Before inserting the needle it is safer to wash it through several times with a 1 in 20 solution of carbolic acid, and care must be taken to keep the needle perfectly steady while it is in the joint.

In some cases a **bursa**, situated in the neighbourhood of a joint, is seriously bruised, and becomes inflamed: in consequence, there is often troublesome suppuration. When this takes place, free incision into the inflamed part, with antiseptic treatment, will afford speedy and effectual relief to the patient.

Sprains.—When a joint is twisted violently so that its ligaments are either much stretched or partially torn across, though there be no displacement of the osseous surfaces, it is said to be *sprained*. These injuries are exceedingly painful and troublesome in their consequences. They most frequently occur to the wrist-, knee-, and ankle-joints. The pain is very severe, and often sickening. The intensity of the pain in a sprain is very remarkable when we reflect on the low degree of sensibility possessed by ligaments in the normal state. They may be cut and divided on the cross without pain, but if stretched in a longitudinal direction or twisted, so as to tend to separate the articular surfaces, pain of the most intense character is at once set up—a wise provision of nature guarding against articular displacements. At the time of the sprain a certain amount of blood is effused into the articular cavity and the surrounding tissues, in consequence of which the limb in a few days becomes discoloured for some distance above and below the joint. The sprain is rapidly followed by swelling and inflammation of the joint and investing tissues, often very chronic and tedious. As the inflammation subsides, stiffness and pain in using the part continue for a considerable length of time, and are in some cases followed by a kind of rigidity and wasting of the limb. In individuals of a rheumatic or gouty habit of body, the inflammation of the joint consequent on the sprain is often most tedious and chronic, and will yield only to appropriate constitutional treatment. In strumous subjects, destructive disease of the joint may ultimately be induced.

Treatment.—If the sprain be slight, rubbing the part with a stimulating embrocation, and giving it the support of strapping or a bandage, are all that need be done. But if it be at all severe, more active measures must be had recourse to. These must vary according to the condition of the joint when the Surgeon sees the patient; but they are all conducted on the principles of securing perfect rest, and subduing inflammation. In the vast majority of these injuries all that is necessary is to put the part at rest for two weeks. The amount of discoloration that often follows a sprain is sufficient evidence

of the extent of the laceration of the ligaments that has taken place. For the repair of this rest is as necessary as for the healing of an open wound or the union of a broken bone. As a rule, however, unless the Surgeon makes it impossible, the patient, finding that he can still use the joint, although with some pain, continues to do so. This is the reason that sprains are so often tedious in the cure, and so frequently leave weakness or stiffness behind. If the Surgeon therefore see the patient immediately on the occurrence of the accident, or before much swelling have set in, the best plan is to envelope the joint either in a flannel bandage or in a thick layer of cotton-wool, over which a plaster-of-Paris-bandage is to be applied. The plaster should be kept on for two weeks, at the end of which time the patient may cautiously use the joint. This method of treatment, which comprises rest, perfect immobility, and compression of the joint, puts it into the best possible condition for the repair of the injured articular structures, and for the prevention of consecutive inflammation. Another plan of treatment is to strap up the joint very firmly with long strips of soap-plaster, but this is not as efficient a means of procuring rest. Should the patient not have been resting the joint, and should inflammation with much swelling have set in, in most cases the best treatment will be the application of a starched bandage, as a plaster-of-Paris-apparatus is apt to become loose as the swelling subsides, and it cannot be opened and refilled with cotton wool as the starched bandage can. Should the inflammation be too acute for the immediate application of a rigid apparatus, the joint may be put on a pillow and covered with a piece of linen-rag, well moistened with an evaporating lotion or kept wet by means of irrigation, or covered with ice-bags. Should this not check the inflammation, leeches may be freely applied ; and, when the swelling has somewhat subsided, the joint should be supported with an elastic roller and plasters, a plaster or starched bandage, or leather splints. In the more advanced stages, when pain and stiffness alone are left, it should be well douched with cold water twice a-day, and afterwards rubbed or kneaded with soap-liniment, until its usual strength and mobility are restored. This, however, very commonly does not occur in sprains of the knee and ankle for many weeks ; a degree of painful stiffness being left.

Persistent Pain or Weakness in a joint after a severe sprain may arise from various causes, each of which requires appropriate treatment. The following are the chief conditions requiring attention.

1. *Adhesion within the joint and in the neighbouring synovial sheaths* consequent upon the inflammation following the sprain. In this condition the swelling has completely subsided, but the movements of the joint are limited and any attempt to forcibly exceed the limits is accompanied by intense pain, usually localized at one spot. This form is best treated by forcible movement or wrenching under an anæsthetic.

2. *Imperfect repair of the torn ligaments* usually results from want of rest during the treatment. There is little or no swelling, and the movements of the joint are perfect, but there is a sense of weakness, accompanied by slight pain if any strain is thrown upon the injured ligament. This is best treated by fixing the joint for three or four weeks in a plaster of Paris bandage, after which an elastic support may be worn for some time.

3. *The effusion may have been imperfectly absorbed.*—The joint presents then the ordinary appearances of chronic synovitis, and must be treated for that disease. (See Synovitis).

4. In *Strumous, Gouty,* and *Rheumatic* subjects the inflammation following a sprain may assume the form characteristic of these constitutional conditions, and must be treated accordingly. (See Diseases of Joints.)

5. In severe sprains of joints, more especially of the knee, ankle, and shoulder, it often happens that there is *a slight displacement of the articular surfaces.* This may happen at the time of the sprain, being primarily and directly occasioned by the violence that twists and sprains the joint, or it may be secondary, coming on at a later period, owing to the constrained position in which the injured articulation has been kept for some length of time. Any way, if allowed to remain, it interferes seriously with the free mobility of the joint. In order that this be maintained, the most accurate co-aptation of the articular surfaces is necessary. If there be the very slightest deviation from the accuracy of this "fit," they become locked in movement, and all motion becomes painful. This is especially the case in the hinge-joints, as the knee and elbow. In the ball and socket joints, more especially in the shoulder, the head of the humerus is apt to be thrown very slightly forwards on to the edge of the glenoid cavity, where it becomes fixed, all movements of the joint being exquisitely painful.

In all these cases of slight displacement connected with sprains that do not amount to dislocation, properly so called, but where there is only a very slight want of true co-aptation between the articular surfaces, the patient should be put under anæsthesia, and the joint "wrenched," so as to replace the bones and restore freedom and ease of movement.

So, also, at a later period, when after a severe sprain, a stiff, painful, and possibly slightly distorted joint is left, no time should be lost in "wrenching" it. By this means, adhesions at this stage are broken down, and the proper "fit" of the bones restored. By neglecting this very simple treatment and leaving the joint but partially and only painfully mobile the Surgeon is much discredited, and the patient drifting into the hands of the "bone-setter," has his limb "wrenched" into utility and ease by a most simple manœuvre.

WOUNDS OF JOINTS.—A joint is known to be wounded, when synovia escapes from the aperture or when the interior of the articulation is exposed. If there be any doubt as to the wound having penetrated the synovial membrane, no attempt should be made to ascertain this by probing, as in this way the very occurrence that is to be dreaded may be induced by the Surgeon. If the wound be of sufficient size a careful and gentle examination may safely be made with the finger. In all doubtful cases the wound must be treated as one of the joint, and the question whether it penetrated or not will often be cleared up by the symptoms that supervene.

Pathology.—In no class of injuries are the effects of the admission of air and of the consequent decomposition of the discharges more marked than in wounds of joints. The most extensive subcutaneous injuries of joints are recovered from, as a rule, without a serious symptom. Thus a simple dislocation of a large joint, although accompanied by laceration of the capsule, tearing of neighbouring muscles, and abundant extravasation of blood, is almost invariably recovered from with but little pain or inflammation, and with perfect restoration of the mobility of the joint. On the other hand a small incised wound, such as might be made by a stab from a pocket knife, may be followed by the severest constitutional symptoms and the most acute destructive inflammation of the joint, or as it is called **Traumatic Arthritis**

The reason of this is not difficult to find. A joint consists in most cases of an irregular cavity, capable of very considerable distension and very difficult to drain perfectly. The effect of a wound is to cause an effusion into the cavity first of blood and, almost immediately after, of synovia, mixed with serous exudation from the vessels of the synovial membrane. The consequence is that the whole cavity becomes more or less tensely distended, according to the amount of drainage given by the wound, with putrescible matter, and this is brought into direct contact with the unpurified air by means of the external opening. The causes of decomposition thus being admitted, in the great majority of cases putrefaction follows, and the whole synovial membrane and the surfaces of the cartilages become bathed in septic fluid. As the result of this the most acute inflammation is set up, rapidly reaching the stage of suppuration. This soon extends to the ligaments, which become softened and yield, allowing the articular surfaces to become displaced; at the same time abscesses form outside the joint, either from perforation of the capsule or by extension of the inflammation through it; these may burrow widely beneath the muscles surrounding the joint. Within the joint the cartilages perish, in consequence of the irritation to which they are exposed, they become loosened from the subjacent bone, and by a process rather of maceration and friction than of true ulceration they become worn away at those points at which the articular surfaces have been most continuously in contact; the bone beneath is thus exposed, and from the combined irritation of the pressure of the opposed surfaces, a certain amount of friction, and the contact of the septic discharges, ulceration spreads rapidly into it. Thus the whole articulation becomes completely disorganized. This process is necessarily accompanied by very high fever. There is no surface in the body from which absorption can take place more rapidly than from the synovial membrane of a joint; as soon, therefore, as it becomes bathed in septic matter severe septic fever is developed; the intensity of the fever corresponding with the size of the joint and the extent of surface from which absorption is taking place. When the interior of the joint becomes covered by granulation-tissue, which presents a more or less efficient barrier to further absorption—that is to say, by about the eighth or tenth day—the fever subsides. Before this, however, the patient may perish from septic poisoning, or the case may become complicated by some infective process, as septicæmia or pyæmia. The serious consequences, therefore, that follow wounds of joints may be traced entirely to the following causes: the accumulation of blood and serous effusion in the cavity of the joint, and the decomposition of the discharges consequent upon the admission of unpurified air, aggravated in some cases by want of rest and by the unhealthy constitutional condition of the patient and the bad hygienic surroundings in which he may be placed.

There are two ways, however, in which, without any special treatment, a wounded joint may escape the destructive processes above described; first, if, the wound being very small and the instrument inflicting it perfectly clean, no air be admitted, union of the external opening may take place by the first intention, and the after progress of the case may be the same as in a subcutaneous injury; secondly, if the wound be very large, so as to give perfect drainage to the cavity and thus to prevent the retention within it of decomposable matter, recovery may take place with comparatively little local inflammation or constitutional disturbance. It is a medium-sized wound, one

too large to heal by the first intention and too small efficiently to drain the joint, that is the most dangerous. Of all wounds of joints, gunshot-wounds are necessarily the worst. In these, the aperture cannot be closed and united by the first intention; and the track of the ball must almost inevitably suppurate. The bones are also usually splintered, and foreign bodies of various kinds are introduced into the articulation; hence the most extensive, disorganizing, and fatal mischief commonly ensues.

In a case of traumatic arthritis if we have the opportunity of examining the joint, the appearances will vary with the time after the infliction of the injury. At the end of from twenty-four to forty-eight hours the synovial membrane will be found intensely red and injected, its surface lustreless, its fringes swollen; and the cavity will contain a quantity of turbid fluid still retaining some of the characters of synovia, but thinner than natural, in which microscopic examination would probably reveal the presence of micro-organisms. Later on, at the end of a week or ten days, the synovial membrane will have lost its characteristic appearance, being concealed by granulation-tissue, the surface of which is entirely or in part covered by a thin grey sloughing layer. The cartilages have lost their natural lustre and smoothness, their surfaces are yellowish in colour, and partial erosion will have commenced at the points at which the opposing articular surfaces have been in contact. The ligaments are swollen and softened and the tissues surrounding the joint œdematous and infiltrated with inflammatory products. Such fluid as the joint contains will be thick pus. In the more advanced stages of the disease, when the joint has been suppurating perhaps for many weeks or even months, it will be found that it is difficult to recognize the synovial membrane, ligaments and capsule, all being lost in the mass of inflammatory products infiltrating their structures, giving them a uniform semi-transparent appearance. The cartilages are perforated in their central parts, at the circumference they have almost the appearance and feel of wet leather. The bones are exposed and are ulcerating superficially, the surface being rough and of a dark red colour. Occasionally in the latest stages, if the joint has been kept at rest, granulations may have sprung up from the opposing bony surfaces, and having coalesced, there may be some actual osseous union of these surfaces. If recovery does take place in such a case it is effected by complete bony union between the articular ends, with gradual absorption of the inflammatory products and development of dense cicatricial tissue around the site of the joint. Microscopic examination shows nothing but the ordinary signs of inflammation in the various structures entering into the composition of the joint.

Symptoms and Effects.—The severity of the wound of a joint depends chiefly on the size of the articulation and the nature of the wound, but is also materially influenced by the age and health of the patient. Small subcutaneous wounds, such as are inflicted for the removal of loose cartilages, may usually be made with perfect safety, if proper precautions be taken to prevent the intrusion of air and the instruments be perfectly clean. But with joints laid open as the result of accidents, everything depends on the prevention of traumatic arthritis, by the establishment of good drainage and the exclusion of the causes of decomposition. This latter condition may be difficult from the presence of dirt or foreign bodies on the cavity of the joint.

It is especially in adults that unfavourable results ensue; in children extensive injuries of large joints may heal favourably; though if the child be strumous, chronic destructive inflammation is apt to be set up.

If the patient escape the dangers of *septic* arthritis and the wound unites by the first intention, there is usually some effusion into its cavity, with heat and pain, which subside in a few days, leaving the articulation weak, tender and stiff for some considerable time. This period of swelling is one of considerable anxiety to the Surgeon, but if by the third day the symptoms begin to subside, and especially if there be no marked rise of temperature, he may confidently look forward to a speedy recovery. Should septic arthritis supervene, the joint within a few hours of the infliction of the injury, swells, becomes hot and painful, and throbs. The pain steadily increases, becoming tensive and excessively severe. If the aperture be large, synovia freely escapes, which soon becomes mixed with inflammatory products. If it be small, little more than a puncture, the joint swells and fills with pus, which will either escape through the original wound or find an outlet for itself, bursting through the capsule and burrowing widely beneath the fascia of the limb before reaching the surface. The swelling at first assumes the outline of the synovial membrane, but as soon as the inflammation has extended to the ligaments it becomes globular or oval. The skin over the joint becomes red and œdematous. The limb is placed in a position of semiflexion. There are startings in the limb, worse at night, waking the patient should he fall asleep. The pain becomes agonizing should the joint be moved in the slightest degree. The constitutional disturbance becomes very severe, the temperature often rising as high as 105° Fahr. The pulse is rapid and bounding, the tongue dry, the face flushed, and there is frequently delirium at night. The patient may perish at this stage from the intensity of the septic fever. In other cases he may be early attacked by septicæmia or pyæmia.

If the patient survive this acute period, abscesses form around the articulation, and the discharge from these, as well as from the joint, with the chronic poisoning from absorption of the products of putrefaction, may gradually prove fatal by exhaustion. Should this danger be passed through and the patient eventually survive, it will be with an ankylosed limb, the utility of which is greatly impaired.

Treatment of Wounded Joints.—The first point to be determined must be whether amputation or resection should be performed, or an attempt made to save the injured joint. If the joint have been extensively laid open, with much contusion and laceration, complicated, perhaps, with dislocation, or with fracture and splintering of the bones, no attempt to save the joint is likely to succeed. In these unfavourable circumstances, however, in the upper extremity, and even in the ankle, the limb may not unfrequently be saved. If the bones be comminuted, the removal of splinters and resection of the articular ends may advantageously be practised in many cases, more particularly if the patient be young and sound in constitution and the soft parts not too extensively damaged. But, if these be largely lacerated and widely contused, or the patient aged or broken in health, amputation is imperatively called for. This is especially the case when the knee is injured; extensive lacerations of the joint, if complicated with dislocation or with comminution of the bones, being cases for immediate amputation.

In all other cases an attempt may be made to save the joint. In fact the

prognosis in cases of wounded joints has been materially improved, and the treatment not only greatly simplified, but rendered far more successful than formerly by the employment of antiseptics and drainage. Indeed the whole surgery of joint-wounds has been completely revolutionized, and cases that a few years ago were at once submitted to amputation are now saved without difficulty, and this applies not only to incised wounds but equally to those of a lacerated character or that are complicated even with fracture of the articular ends.

If then it be determined to save the joint, we must keep three objects steadily in view: first, the synovial cavity must be thoroughly drained; secondly, the joint must be kept perfectly at rest, and firmly fixed so that movement is impossible; and thirdly, the discharges must be prevented from decomposing by some efficient system of antiseptic treatment. To drain a joint perfectly, as before stated, is not always easy, but every articulation can, without difficulty, be sufficiently drained to prevent the development of tension in its cavity. If an efficient system of antiseptic treatment can be carried out, minor imperfections of drainage are, however, of little consequence.

The Antiseptic Treatment of a wounded joint is carried out on exactly the same principles as in that of any other wound. The wound must, if necessary, be enlarged; the cavity of the joint is then well syringed out with carbolic acid solution in water (1 to 20). This is best done by means of a stiffish piece of India-rubber tubing long enough to reach to any part of the joint, fixed on the end of a syringe. The joint may be carefully moved at the same time, so that the lotion may find its way to every part of the articulation. The fluid is then squeezed out of the joint, a drainage-tube inserted, and the wound closed by sutures. If the case be one of a large lacerated wound, with dirt ground into it, it must be carefully cleaned with a sponge. If the wound is in such a situation that it is not likely to drain well, a counter-opening may be made on a probe at the most dependent part into which another tube may be passed. The gauze-dressing is then applied and the limb fixed on a splint or by some rigid apparatus in such a way that the slightest movement is impossible. The drainage-tubes can usually be removed at about the end of the first week, but this will depend upon the amount of discharge. Great care must be taken not to move the joint at the dressings. Instead of applying the carbolic gauze, the joint after being disinfected may be wrapped in a mass of iodiform or salicylic wool and left undisturbed, unless the temperature rise over 101° Fahr., with severe pain, till the discharge soaks through, or till the wound may be supposed to be healed. A good plan of treating these cases is to apply one dressing of carbolic gauze to receive the first twenty-four hours' discharge, and at the end of that time carefully to remove the sodden dressing and apply iodoform-wool, enclosing the limb in a plaster-of-Paris-bandage to maintain rest.

Should antiseptics not be available, the following treatment should be adopted. If the joint be opened by a puncture, or small clean-cut wound, this may occasionally be closed by bringing the edges together, and placing a piece of lint soaked in collodion upon it, or a strip of plaster washed over with resin varnish. The joint must then be placed in a splint (plaster of Paris is the best), so as to be rendered absolutely immovable, and should then be surrounded by India-rubber bags containing pounded ice, or kept cold by the

application of Leiter's tubes (p. 197). In fact, the best chance of avoiding further mischief lies in the exclusion of air, perfect rest, and the continuous application of dry cold. In this way inflammation may be prevented, and union of the wound take place under the plaster; but in the majority of cases the injury is followed by so abundant a secretion of synovia, that the dressing becomes loosened by the tension and outward pressure of the accumulated fluid which escapes from under it. If the preventive means fail to arrest inflammation, and the joint swell, becoming red, hot, and throbbing, with much constitutional disturbance, the cold applications must be removed and heat substituted in the form of fomentations. The synovial cavity should then be emptied by means of the aspirator. If the fluid that be withdrawn be merely turbid synovia, leeches may be applied and the hot fomentations continued. Opium may be given to relieve pain. In this way the symptoms may be relieved and the joint recover. Should the fluid withdrawn be pure pus, or contain a large proportion of pus, it is useless any longer to attempt the closure of the wound.

When suppuration has come on, long and free incisions should be made into the joint, on each side, if possible, and at the most dependent part of the capsule, so as to allow a ready exit to the pus. If this be done thoroughly, and perfect rest maintained afterwards, the symptoms are immediately relieved, and ultimately recovery may take place, usually with ankylosis, but occasionally with some degree of mobility. Small incisions into the joint are worse than useless; by a small incision the pus cannot be evacuated from a deep and complicated joint, but air is admitted, and the result is to encourage the decomposition of the discharges, and to cause severe septic fever and possibly pyæmia; by making free and early incisions, however, and thus establishing perfect drainage, but little decomposable matter is left in the cavity of the joint, and the evils of decomposition are reduced to a minimum. The complete relief of tension procured by such incisions reduces the local inflammation and saves the patient much pain. After the incisions have been made, it is better to avoid poulticing or simple water dressing, as these encourage putrefaction. The wound must be syringed with some antiseptic solution as Condy's fluid, carbolic lotion (1 in 40), or tincture of iodine and water (ʒij to Oj), and be dressed with carbolic oil (1 in 10), or terebene and oil (1 in 6), or a strong lead and spirit lotion. If boracic-acid-lint be at hand, that doubtless forms the most efficient dressing, applied warm like a poultice and changed frequently. In the absence of all antiseptic material the open treatment, or the simple application of oil or lard will be the best. If the case proceed favourably, the discharge will gradually lessen, and the constitutional disturbance subside. The joint must then be placed in such a position, that, when ankylosis results, the limb may be serviceable to the patient. If, however, as very frequently happens when the larger joints are wounded, the suppuration within the articulation, and the abscesses that form outside it, reduce the patient to a hectic state, secondary amputation speedily becomes inevitable.

Wounds of Individual Joints.—To the preceding general principles I have little to add with respect to wounds of the individual joints.

The **Hip and Shoulder** are so deeply placed, and so well protected, that they can scarcely be wounded except as the result of gun-shot injury, the treatment of which condition has already been discussed (pp. 344, 346).

Wound of the **Knee-joint** is one of the most common and most severe of

such injuries. Those caused by gun-shot violence have already been described (p. 345). When produced by a puncture or clean cut, antiseptic treatment and immobility will usually ensure a cure without the functions of the joint being in any way impaired. Thomas's knee-splint well applied will be found the most convenient form of apparatus for fixing the joint. Should suppuration occur, the joint must be laid open unsparingly. The finger should be inserted at the original wound, if it be situated towards the front of the joint, and pushed down to the most dependent part of the synovial pouch; here the tip of the finger may be made to project and be cut down upon. A probe pointed bistoury is then to be inserted and the incision extended till it reaches from the head of the tibia to the upper limit of the synovial pouch. The knife should not be held horizontally, but slanted backwards so as to facilitate drainage. The opposite side of the joint must then be treated in the same way. Even after this amputation is not unfrequently necessary, and the incisions above described can be used in performing the operation. The abscess in these cases will often form deeply, the pus bursting from the joint by the upper part of the synovial pouch, and burrowing up the thigh under the vasti, separating them from the bone, and reaching sometimes as high as the trochanter before it is detected. At the time the synovial pouch gives way the relief of tension may cause a deceptive abatement in the severity of the symptoms ; but soon the limb swells up to the trochanters, becomes very tense, painful, hot, and œdematous, with great constitutional disturbance and high fever, though the joint may be but little swollen, and many days will often elapse before fluctuation can be again felt in it or in the thigh. It is this absence of swelling in the knee itself that may mislead an inexperienced practitioner. At length the abscess may approach the surface near the knee ; and, on an incision being made, an immense quantity of pus is discharged. It is this depth in the limb at which the abscess is seated that gives rise to the difficulty in its detection, the violent constitutional disturbance it occasions, and its extreme danger. I have never seen abscess form amongst the muscles of the leg as a consequence of injuries of the knee-joint, unless the tibia had been fractured as well as the joint opened.

For the penetration of the knee-joint by needles, see p. 324.

Wounds of the **Elbow** and **Ankle-joints**, when simple, as in punctures, usually admit of closure and of being healed, leaving a sufficiently useful and mobile articulation. When they are complicated with fracture of the neighbouring bones, the soft parts not being too extensively injured, resection of the injured articulations is the proper course to adopt; if there be much laceration of soft parts with comminution of the bones, amputation, especially in the case of the ankle, will be required.

Wounds of the **Wrist-joint** are peculiarly dangerous, on account of the extent and complexity of the synovial membrane that enters into its conformation. Should suppuration be set up, some of the carpal bones may necrose. In these circumstances, if the patient be in good health and not too old, excision of the joint will save a very useful hand; when excision is not practicable, amputation must be performed, if possible, by a flap taken from the palm, only the diseased articular ends of the radius and ulna being removed. In some cases the patient may recover without operation, but a stiff and comparatively useless hand will usually be left.

Dislocations will be described in Chapter XXII.

CHAPTER XX.

FRACTURES.

The management of fractures constitutes one of the commonest duties of the Surgeon, and hence the consideration of all that relates to their nature and treatment is of the utmost importance.

A fracture may be defined as a sudden and violent solution of continuity in a bone; but by the term fracture it is convenient to describe other lesions, which, strictly speaking, are not comprised in the definition. The displacement of an epiphysis from the shaft of a bone is not really a *fracture* but a *separation;* as is also the displacement of a costal cartilage from a rib.

Causes.—Fractures are almost invariably the result of local causes, but the liability to their occurrence is more or less modified by certain predisposing circumstances.

Local Causes.—Fractures may occur from the application of external violence, or from muscular action.

External violence may be applied in two ways: directly or indirectly.

The worst forms of fracture are occasioned by **direct external violence,** the weight or blow crushing and splintering the bone, as by the passage of a heavy wheel or a gun-shot-injury. When the bone is broken by direct violence, the fracture is always at the seat of injury, and is often complicated with considerable mischief to the soft parts, the result of the same force that breaks the bone.

Indirect violence may break a bone in two ways. One that is more commonly talked of than seen is by *contrecoup,* in which, when a blow is inflicted on one part, the shock that is communicated expends its violence on the opposite point, where the fracture consequently occurs. This form of injury is chiefly met with in the head; and, although its occurrence has been denied, I cannot doubt it, as I have seen unequivocal instances.

In the next form of indirect violence occasioning fracture, the bone is broken by being snapped, as it were, between a resisting medium at one end, and the weight of the body on the other. Thus, a person jumping from a height and alighting on his feet, may break his legs by their being compressed between the weight of the body above and the ground below. The long bones are those which are most frequently fractured in this way; and the fracture occurs at the greatest convexity, or at their weakest point. When a person jumps from a carriage that is in motion, although the height of the fall be not great, yet its force is considerable, the feet coming violently to the ground and being suddenly fixed, while the body moves with the same velocity as that with which it was being carried onwards in the vehicle. Hence, fractures received in this way are usually severe, and often compound or comminuted.

Muscular action is not an unfrequent cause of fracture of those bones into which powerful muscles are inserted. This is especially the case with the patella and some of the bony prominences, such as the acromion, which are broken in

the same way that a tendon is ruptured—by the violent contraction of the muscles attached to them tearing them asunder. It is not often that the long bones are so fractured ; but the humerus has been broken by a person striking at but not hitting another, or by suddenly throwing out the arm to seize something that was falling ; and the clavicle has been fractured by a rider giving his horse a back-handed blow. In these cases, however, muscular action may not have been the sole cause, the weight of the limb also tending to fracture the bone. Those bones that do not afford attachment to any powerful muscles, as the cranial, for instance, cannot be fractured in this way. Muscular action also aids in the fracture of bones by indirect violence, thus we see that a sober man who makes a violent effort to save himself more often breaks a bone in a fall than a drunken man who falls like a log.

Predisposing Causes.—These are numerous and varied.

Some bones are especially liable to be broken in consequence of their *serving as points of support.* Thus, when a person falls upon the hand, the shock is transmitted from the wrist-joint through the radius, humerus, and clavicle, to the trunk ; the radius and clavicle, being the weaker bones, are then especially liable to be fractured. So again, the *situation* of a bone, irrespectively of any other circumstance, may predispose it to fracture; the prominent position of the nasal bones, and the exposed situation of the acromion, render these parts peculiarly liable to injury. The *shape* of some bones disposes them to fracture ; thus, a long bone is necessarily more readily broken than a short and thick one ; hence fractures of the tibia and femur from falls on the feet are more common than of the os calcis. *Certain parts of bone* are more commonly fractured than others. Those parts especially into which powerful muscles are inserted, or that are in exposed situations, and hence liable to injury, or have to receive the weight of the fallen body, are often broken. Hence the clavicle, the olecranon, and the neck of the femur, are commonly fractured.

Age exercises considerable influence, not only on the general occurrence of fracture, but on the peculiar liability of certain bones. Though fractures may occur at all ages, even in intra-uterine life (Chaussier has dissected a fœtus that had 113 fractures), yet bone, being elastic and cartilaginous in early age, is less readily broken than when it has become brittle and earthy, as in advanced life. In children, fractures frequently occur at the point of junction between the shaft and epiphysis, where ossification has not as yet become perfect. This separation of the epiphysis in children, the detachment as it were of the terminal points of ossification, occurs chiefly at the lower ends of the humerus and femur, sometimes in the radius and other long bones. As age advances, the compact tissue of the shaft becomes denser and harder, but the cancellous structure of the extremities more dilated and looser : hence fracture of the neck of the femur is especially common in old people. In young persons also, the bone is usually broken transversely, but fractures taking place at a more advanced period of life are generally oblique, and often comminuted : in adults they also more commonly extend into joints than when occurring in early age. In children, more than one half the fractures occurring in the upper limb are of the clavicle ; and in the lower limb, fracture of the shaft of the femur by indirect violence is of extremely common occurrence.

Sex indirectly influences the liability to fracture, men being more frequently exposed to the causes of this injury than women. In women, the bones

that are most commonly fractured are the clavicle, the radius, the tibia, and the neck of the femur ; in men, the shafts of the long bones, the cranium, and the pelvis.

From statistical tables of fractures of the upper limb given by Flower, it appears that below five years of age the liability of the two sexes to fracture is equal. After five, the males steadily increase in liability up to middle life. After forty-five, the number of fractures in females exceeds that in males, in consequence of the extreme frequency in women above middle life of fracture of the lower end of the radius.

Side of the Body.—From the latest statistical accounts collected by Gurlt, Middeldorpf, Lente and others, it would appear that fractures occur with about equal frequency on the two sides of the body.

Time of Year.—The popular supposition that the bones are more brittle in winter, and hence break more readily than at other seasons, is altogether a mistake ; though fractures may be common at this period of the year, from falls being more frequent during frosty weather.

Spontaneous fractures are those which happen without any very distinct cause, or under the influence of violence that would usually be insufficient to occasion it. They arise from various pathological conditions, amongst which the following are the chief. *Atrophy of Bone* occurs naturally in old age, and is, as before stated, a powerful predisposing cause of fracture ; but mere senile atrophy seldom reaches such a degree as to lead to spontaneous fracture. In the same way atrophy from want of use may render the bone brittle, so that a very small force may break it, as we occasionally see in attempted reduction of old dislocations. A much more important form of atrophy is that which accompanies certain forms of disease of the central nervous system, especially general paralysis of the insane. Bruns has collected the records of sixty cases of spontaneous fracture occurring in the insane, and amongst these were many instances of multiple fractures. In some of these cases the bones were found to be greatly atrophied, and in one they were easily cut with a knife. General paralysis is not unfrequently complicated by violent maniacal attacks, and in the necessary restraint at these times it has happened that one or more of the patient's bones have been broken although no undue force has been employed. These cases have more than once given rise to charges of cruelty or manslaughter against the keepers in lunatic asylums. Weir Mitchell states that spontaneous fractures are not uncommon in locomotor ataxy. *Mollities ossium* is, as will be seen when treating of that disease, often associated with spontaneous fracture. *Rickets* is more often a cause of bending or partial fracture under considerable violence, but cannot be said to be a cause of true spontaneous fracture. *Scurvy* was said by the older writers to cause a general weakness of the bones, but later observations have not confirmed this. In children it is said to predispose to separation of the epiphyses. *Constitutional Syphilis* was formerly believed in some cases to cause a general brittleness of the osseous system, but later observations do not confirm this : in every case in which syphilis is a cause of spontaneous fracture some definite local disease, as caries, necrosis, or a gumma, is met with. In the same way the "*cancerous cachexia*," apart from the development of a secondary tumour in the bone, never causes spontaneous fracture. A *sarcoma* growing in or on a bone, or pressing on it when springing from a neighbouring structure, may so weaken it as to cause it to give way spontane-

ously. *Necrosis, caries and abscess of bone* have all been known to give rise to spontaneous fracture, but such a complication is extremely rare. Some rare cases have been described in which there is a *hereditary tendency* to fracture of the bones, without any other recognizable constitutional defect, transmitted from father to son. Thus Greenish records a case in which the grandfather had had several bones broken; he had three sons and two daughters: the youngest son and the two daughters escaped without fractures; the eldest son, who had one bone broken, had two children, the eldest of whom had thirteen and the younger two fractures; the second son, who had two fractures, had five children, who suffered respectively four, four, eight, four, and three broken bones. Lastly, certain cases are met with in which no clear causes can be found: thus fracture of the femur has more than once been met with in young men apparently quite healthy, from the sudden and violent contraction of the thigh muscles, as for instance in pulling off or drawing on a boot, and I have known a gentleman a little above fifty, apparently in perfect health, break his thigh with a loud snap whilst turning in bed. In cases of spontaneous fracture union rarely takes place, or not without much difficulty.

VARIETIES.—Fractures present important varieties as to their *Nature* and their *Direction*. The varieties as to nature depend upon the cause of the fracture, its seat, and the age of the patient.

Nature.—Fractures are divided into two great classes, according as they are unaccompanied or attended by an open wound leading down to the line of breakage in the bone—the first being called *Simple*, the second *Compound*. In the first class are included the **Single Fracture**, where the bone is merely broken across, split, or fissured; the **Impacted**, where one fragment is wedged into another, the compact tissue being driven into the cancellous structure; the **Comminuted** (Fig. 172), where the bone is broken into several fragments at one place; and the **Multiple**, where there are more fractures than one, either in different bones or in different parts of the same bone.

Fig. 172. — Comminuted Fracture made by gun-shot.

When the soft parts are torn through, so that the fracture communicates by a wound with the surface of the body, it is said to be **Compound.** A fracture may be rendered compound in two ways: either through laceration of the soft parts by the same injury that breaks the bone, as when a bullet in traversing a limb, fractures the bone; or else by the protrusion of one of the extremities of the broken fragments through the integuments. This necessarily most frequently happens when the fragments are sharp and pointed, and the coverings thin, as in fracture of the tibia, and may be occasioned by muscular contraction, or by some incautious movement on the part of the patient, or roughness on the part of those lifting or carrying him, driving the fragment through the skin.

It is important to distinguish between fractures that are primarily compound, that is, that are compound from the first or become so within a few days, and those in which a wound leading to the broken bone forms some time after the accident, as the result of inflammation, suppuration, and sloughing, or from other causes. When the fracture becomes compound secondarily, the danger

is greatly lessened, on account of the reparative tissue that has formed at the seat of the injury having closed the medullary canal in such a way that septic osteomyelitis is not likely to occur. The blood-clot and the early exudation are also to a great extent absorbed and the intermuscular spaces around sealed by coagulated inflammatory exudation or granulation-tissue, and thus deep burrowing of septic matter in the limb is not likely to take place, and the danger of septic absorption or pyæmia is greatly diminished.

A fracture is said to be **Complicated** when the injury to the bone is conjoined with other conditions which are perhaps of more importance than the mere fracture; the complication constituting often the most serious part of the injury, and influencing greatly the general result of the case. Thus, a fracture may be complicated with injury of an important internal organ, as of the brain, lung, or bladder; the injury to the organ being inflicted by the projection against it of one of the broken fragments. A fracture is not unfrequently complicated with the wound of one of the principal arteries of the part, as happens especially in the leg, where the tibial arteries, being in close contact with the bone, are often torn by the broken ends. In other cases again, the fracture is associated with injury of a joint or with dislocation.

Besides these varieties of fracture, it occasionally happens that a bone is only cracked, or partially broken. This especially occurs in the bending of bone in children, in which cases the fracture may be **Partial** or **Incomplete**, merely extending across the convexity of the curve made by the bone. This is sometimes called the "*green-stick*" fracture.

Direction.—The direction assumed by fractures varies greatly, and depends materially on the cause of the injury, as well as upon the bone that is fractured.

The line of fracture may run through a bone in three different directions: either *transversely*, *obliquely*, or *longitudinally* to its axis.

The **Transverse Fracture** is the simplest, and is seldom complicated with injury to the neighbouring parts. It chiefly occurs in children, and very frequently between the articular extremity and the shaft of a bone; it unites readily, and is attended by but little displacement. It is most commonly the result of direct violence, but it may arise from muscular action, as in the case of the patella, which is usually broken in this way.

The **Oblique Fracture** commonly occurs from indirect violence; the breaking force being applied to the ends, and not across the shaft. It often runs a long way, more than half the distance of the shaft of a bone, and is more dangerous than the transverse, owing to the obliquity of the fracture causing the ends of the bone to be sharply pointed (Fig. 173), and thus frequently to puncture the skin, or to perforate an artery. It is more tedious in its cure than the transverse, owing to the extent of surface over which the process of repair has to be carried on, and the difficulty of keeping the fragments directly in apposition; hence, also, there is a greater liability to shortening of the limb. It is principally met with in the shafts of the long bones of adults and elderly people.

The **Spiral Fracture** is the result of violent twists, and is most frequently met with in the tibia and femur. In it the fissure runs obliquely round the axis of a long bone. The fracture is usually rendered complete by a second fissure joining the line of the spiral; but it has been occasionally met with in an incomplete form.

The **Longitudinal Fracture** consists of a splitting or fissure of a bone in the direction of its axis (Fig. 173, *b*). Longitudinal fracture, or splitting of bone, is not very common in civil practice ; but in military practice it is frequent, especially from the action of conical rifle-balls. In such cases, when the shaft is struck and shattered, the splitting of the bone may extend widely in either direction—sometimes into the neighbouring joint (Fig. 109, p. 328), although, as Stromeyer has remarked, it usually stops short of this, terminating at the epiphysis. When the fracture is produced by a blow, which need not be a very severe one, upon the articular end, the bone may be split and the joint opened. In flat bones, the fissures may radiate from the spot to which the violence has been applied, forming the **stellate fracture** ; or a sharp instrument may perforate the bone, giving rise to a **punctured fracture**.

Fig. 173.—Oblique and Longitudinal Fractures.

The Separation of the Epiphysis of one of the long bones from the shaft, at the line of junction, is an accident that occasionally occurs in children and young people at any period up to that of the completion of the ossification between the parts. Hence it is met with under the age of 21 or 22. This kind of fracture is always transverse. It is apt to simulate a dislocation very closely ; but the diagnosis may be made by finding that the articulation is always intact, and its movements usually free. Union readily takes place by bone, and the longitudinal growth is consequently in many cases seriously interfered with. Not only are the epiphyses of the long bones liable to this separation through the line of junction, but the same thing may happen to various processes, as the acromion, olecranon, &c. ; and some osseous structures, as the acetabulum and sternum, are apt under external violence to separate into their original component parts.

Signs of Fracture.—The history given by a patient who has broken a bone will usually be that he has met with a violent accident, during which he felt, and perhaps heard, something break or snap, and that, immediately, he found himself unable to move the affected part, and any attempt to do so caused the most agonizing pain. These facts are common to many other injuries besides fractures, and serve merely to direct the Surgeon's attention to the seat of injury. The patient must be carefully stripped, the injured part being disturbed as little as possible, the clothes being cut wherever it is necessary, rather than pulled off, as any violent movement might convert a simple fracture into a compound. The limb being fully exposed, the Surgeon proceeds to examine it first by inspection, secondly by measuring, and lastly by manipulation, comparing it in form and size with the uninjured part on the opposite side. It is better to leave the painful process of manipulation till last, as in many cases the existence of a fracture can be determined without resorting to it. The limb will often show some increase in size, due either to the extravasation of blood round the fracture, which often takes place to a very considerable extent, even without the wound of any principal vessel ; or to the approximation of the attachments of the muscles by the shortening of the limb. Diminished bulk, or flattening, occurs in some cases, in consequence of the weight of the limb drawing the part down, and thus lessening natural

rotundity. Neither pain nor alteration of bulk can be regarded as pathognomonic of fracture.

The more special and peculiar signs of fracture are three: 1. A Change in the Shape of the Limb; 2. Mobility in its Continuity; and 3. The Existence of Grating between the Broken Ends of the Bone.

1. The **Change in the Shape of the Limb**, due to the displacement of portions of the broken bone, is a most important sign of fracture; it manifests itself by a want of correspondence between the osseous points on opposite sides of the body, by an increase or diminution of the natural curves of the limb, by angularity, shortening, or swelling.

In investigating the existence and extent of displacement in a case of fracture, the Surgeon should compare the corresponding points of bone on the opposite sides of the body, and their situation relative to some fixed and easily distinguishable neighbouring prominence on the trunk or uninjured part of the limb. From this the measurements may be taken, by grasping the injured part and the corresponding portion of the healthy limb in each hand, and running the fingers lightly over the depressions and elevations, marking any difference that exists; or, if greater accuracy be required, measuring by means of a tape. In some cases the measurement must not be made between the trunk and the limb injured, or even from one extremity of the limb to the other, as shortening of the whole member might depend on causes other than fracture, such as wasting, disease of joints, or dislocation; when this is the case, the measurement must be taken between different points of the bone injured, and compared with a similar measurement of the sound limb; and in children the length of the uninjured bones of the limb must also be compared in order to ascertain whether the shortening is due to a general want of growth in the limb.

The displacement of a broken bone may be the direct result of the violence which occasions the fracture, the fragments being driven out of their position, as when a portion of the skull is beaten in; or it may result from the weight of the limb dragging downwards the lower fragment, as in a case of fractured acromion. In some cases it is either occasioned or greatly increased by the direction of the fracture. Thus, in several cases of broken tibia which have been under my care, the line of fracture being oblique from above downwards, and from before backwards, I have found the upper end of the lower fragment project considerably forwards, sliding, as it were, along an inclined plane in the upper fragment; and in one of these cases, which I had an opportunity of dissecting after amputation, the direction of the fracture had evidently determined the direction of the displacement. In transverse fractures there is often but slight displacement.

Muscular contraction is, however, without doubt the great cause of displacement: hence it has been found that, in paralysed limbs which are fractured, there is but little deformity. The contraction of the muscles of the part approximating their points of attachment, draws the most movable fragment out of its normal position, owing to the support or resistance offered by the bone being removed. The other causes that have just been mentioned, tend greatly to favour this kind of displacement; but in some cases, as in fractured patella, the displacement is entirely muscular, and in all fractures of the long bones it is due chiefly to muscular contraction.

The **Direction of the Displacement** is influenced principally by the direction of the fracture, the position of the limb, and muscular action; it may be angular, transverse, longitudinal, or rotatory.

In the *angular* displacement there is an increase of the natural curvature of the limb, the concavity of the angle being on the side of the most powerful muscles; thus, for example, in fracture of the thigh, the angle projects on the anterior and outer side of the limb, because the strongest muscles, being situated behind and to the inner side, tend, by their contraction, to approximate the fragments on that aspect. This displacement occurs principally in oblique and comminuted fractures.

The *transverse* or *lateral* displacement occurs when a bone is broken directly across. The fragments often hitch one against another, so being, as it were, entangled together, and in this case there is often but very little deformity.

Longitudinal displacement is invariably shortening when the fracture occurs in the shaft of a long bone. It is due in most cases to muscular action, the broken ends of bone being brought together so as to overlap or "ride" over one another. In other cases, the shortening may be owing to the impaction of one fragment in the other. In some cases there is preternatural separation of the fragments, the weight of the limb tending to drag the lower one downwards, or muscular contraction drawing the upper one away from it, as in fracture of the patella.

The *rotatory* displacement may be owing to the contraction of particular sets of muscles, twisting the lower fragment on its axis as well as producing shortening of the limb. Thus the supinators in some fractures of the radius have a tendency to rotate the lower fragment outwards. In other cases the line of obliquity of the fracture may determine the rotatory displacement; and in the lower limb the weight of the limb will always turn the lower fragment outwards, just as the limb of a dead body rolls on to its outer side.

2. The occurrence of **Preternatural Mobility in the Continuity** of a bone cannot exist without fracture, and separation of the fragments from one another; hence, its presence may always be looked upon as an unequivocal sign of broken bone. But fracture may exist without it: thus, it occasionally happens that fracture takes place, and, owing to the impaction or wedging together of the fragments, mobility is not perceived.

3. Another sign of much value in practice is the occurrence of **Crepitus** or rather of the **Grating together of the Rough Surfaces of the Broken Bone**, which can be felt as well as heard on moving the limb. This grating can occur only when the fragments are movable and in contact, and is especially perceptible when the rough ends of the broken bone are rubbed directly against one another. It is not, however, an invariable accompaniment of fracture; being absent in some cases, in which the fracture is firmly impacted or the fragments are widely separated. It must not be confounded with the crepitation that occurs in the limbs from other causes, as from emphysema, or from the effusion of serous fluid into the sheaths of the tendons, which gives rise to a peculiar crackling sensation, very different from the rough grating of a fracture. There is a species of false crepitus also experienced sometimes in injuries of joints, consisting of a snap or click rather than of true grating, which is sometimes mistaken by inexperienced practitioners for true crepitus of broken bone. The roughened surfaces of a joint in the later stages of chronic rheumatic arthritis will, however, give rise

to a grating which it is very difficult to distinguish from that of a broken bone. As a rule it is finer and more regular than the crepitus of a fracture.

In some cases in which the mobility cannot be clearly felt, the patient will complain of pain at the seat of fracture when an attempt is made to find it, or when a distant part of the bone is pressed on. This is often a very useful means of diagnosis in fractures of the fibula and ribs.

It will thus be seen that none of these three signs alone is absolutely to be relied upon, and it usually requires a combination of at least two of them to determine whether fracture exists. In ascertaining the existence of a fracture, the Surgeon should make the necessary manipulations with the utmost gentleness, but yet effectually, so that no uncertainty may be allowed to remain as to the seat and nature of the injury, more especially when it occurs in the vicinity of a joint. The increased mobility may be ascertained by fixing the upper fragment and rotating the lower portion of the limb; the crepitus by drawing down the lower fragment, so as to bring the rough surfaces into apposition, and then grasping the limb at the seat of fracture with one hand, and rotating it gently with the other. The displacement must be ascertained by measuring the limb carefully in the way that has been directed, and by comparing the injured with the sound side.

Diagnosis.—The diagnosis of an ordinary fracture is seldom attended by any material difficulty. The co-existence of displacement, of abnormal mobility, and of crepitus, will usually enable the Surgeon at once and readily to pronounce with certainty its existence, when it is *simple*. When it is *compound*, there is frequently the additional evidence afforded by the protrusion of the end of one of the fragments; and if it be *comminuted* as well, the loose splinters will be readily felt.

There are, however, two conditions that render the detection of a simple fracture occasionally difficult. The first is, when only one of two or several contiguous bones is broken; the other, when the fragments are impacted.

When only one bone is broken in a situation where there are two or more, as in the leg, fore-arm, metacarpus or metatarsus, very close and careful manipulation of the injured bone may be required. The Surgeon must run his finger carefully over the most projecting ridge, feel for slight inequality or œdema at one part, or perhaps he may elicit the faintest occasional crepitus on fully and deeply moving the bone at the seat of suspected fracture; or, failing this, severe pain may be elicited in the line of the bone by forcing its two extremities towards each other, or by applying force in such a way as to bend it.

In the case of impaction the diagnosis is even more difficult. Here no crepitus, and no preternatural mobility, can be found; but the Surgeon must be led to his diagnosis by the recognition of the peculiar displacement and distortion which may be characteristic of the particular fracture, as, for instance, the deformity of the wrist in impacted fracture of the lower end of the radius.

The difficulties of diagnosis in fracture of a single bone, or in an impacted fracture, are necessarily most seriously increased if there be much extravasation of blood into the limb; or, when the fracture is through an articular end, if there should be much effusion into the neighbouring joint. In these cases of doubt it is wiser to put up the limb as if there were a fracture, and to wait for the subsidence of the swelling before the diagnosis is finally determined. It is

far better to put up an unbroken limb unnecessarily than to neglect to put it up if fractured.

As has already been stated, the existence of a fracture when *compound*, and more particularly if *comminuted*, is usually readily determined. Here, the great mobility, the protrusion of fragments or splinters, and the ready crepitus, will seldom allow the Surgeon to be in error. Should any doubt exist, the introduction of the finger into the wound will enable him to determine with certainty, not only the existence, but the condition and extent of the fracture; but on no account must a probe or metal instrument of any kind be used, or a simple fracture complicated with a wound may accidentally be made compound. But with all the assistance that may thus be afforded, the very existence of a bad compound and comminuted fracture may be unsuspected for many days, even though most careful examinations have been made with the view of ascertaining its presence. Of this important fact, which may have weighty bearings in medico-legal investigations, the following case is a good illustration. A young man was shot with a wooden ramrod through the left hand and shoulder, by the accidental explosion of his gun whilst he was loading it. The ramrod struck the humerus three inches below the shoulder-joint, full on its fore part. It was splintered against the bone, the fragments passing on each side, and mostly escaping through two apertures of exit posteriorly; some passing to the inner side between the large vessels and the bone, the others to the outer side between it and the deltoid. The patient was brought to the Hospital, where I saw him a few hours after the injury, and, enlarging the wounds, extracted a number of splinters of the ramrod from around the bone. The limb was carefully examined, not only by me, but by several other Surgeons present, to determine whether the bone had been fractured, or the joint injured. There was no sign of fracture to be detected—no shortening, no mobility, no crepitus, no inequality when the fingers were freely passed into the wounds, no displacement at all. As no fracture appeared to exist, the limb was laid on a pillow, and irrigation employed. Diffuse cellulitis set in, followed by extensive and deep suppuration in the limb. On examining this, with the view of giving a free exit to the discharges, eight days after the accident, displacement and crepitus were for the first time found, and it became evident that the humerus had sustained a comminuted fracture. The patient died of pyæmia; and after death the bone presented the appearance here given (Fig. 174), a long splinter having been detached in a longitudinal direction, A B, and the shaft broken across at C. Here, then, was not only a compound, but a comminuted fracture, detected for the first time a week after the infliction of the injury. It appeared probable that the blow of the ramrod had fractured the bone longitudinally, detaching the large splinter, which had become impacted; and that the shaft still held together by a narrow bridge of bone at C, which being broken across subsequently in moving the limb, now become heavy with inflammatory infiltration, led to the shortening of the limb and the lateral displacement of the fragments.

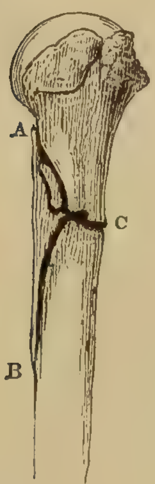


Fig. 174.—Comminuted Fracture of the Humerus without displacement.

Union of Fractured Bone.—A fractured bone is ultimately united by the formation of new bone around, within, and lastly between the broken

fragments. In certain fractures in which the fragments cannot be brought into accurate apposition, as in those of the patella and olecranon, union is effected by fibrous tissue, and, under various abnormal or constitutional conditions that will be hereafter considered, the same form of union may occur in any part of the body.

The new bone that constitutes the bond of union is termed **Callus.** In most cases a larger quantity of this is developed than is permanently left. This temporary formation of bone goes by the name of the **provisional callus.** It is formed partly external to the fracture, incasing the broken ends, and partly in the medullary canal, so as to include the fragments between layers of new bone, and thus maintain them in contact. That which is permanently left, and which intervenes between the broken ends, is called the **definitive callus.** The process of union varies somewhat in simple and in compound fractures.

Union of Simple Fractures.—Our knowledge of the production of callus and the mode of union of a broken bone is derived from experiments on animals, but there is no doubt that the process is essentially the same in man, slightly modified in some cases by the more perfect immobility which is obtained by treatment in the human subject. The subject has been investigated by numerous observers for the last 150 years, amongst whom the following are perhaps the most important: Duhamel, Haller, Bordenave, John Hunter, Dupuytren, Breschet, Villermé, Stanley, Paget, Billroth, Gurlt, and Bajardi. All observers may be said to be more or less closely agreed as to the coarser changes observed in the union of a bone, but there is still considerable difference of opinion with regard to the essential nature of the process and the histological appearances accompanying it.

The process of union of a broken bone, as it is observed experimentally in an animal, may be divided into distinct stages. First, the period of inflammation and exudation lasting from the time of fracture to about the end of the third day. Secondly, the period of growth of the soft provisional callus externally from the periosteum and surrounding structures, and internally in the medulla, and this lasts till about the tenth to fourteenth day. Thirdly, the period of ossification of the provisional callus, lasting to about the end of the fourth or fifth week. Fourthly, the period of the formation and ossification of the definitive callus between the actual broken ends of the bone. This commences after the provisional callus has become firm, and is not completed till a late period. Lastly, the excess of callus is absorbed, and any irregularities rounded off. This is not completed till many months after the bone has been firmly united. These processes must now be considered more in detail.

If the part be examined within a few hours of the fracture, it will be found to be surrounded by an abundant extravasation of blood; this not only surrounds the actual fracture, but extends some distance in the intermuscular spaces of the limb, and frequently also in the areolar tissue beneath the deep fascia. The muscles which lie in close contact with the bone, or arise from it, at the point of fracture, are more or less extensively lacerated; the periosteum is as a rule completely torn through, and separated from the broken ends for a short distance on one or both sides, leaving a ragged edge. In some cases the periosteum on one side may be intact, and it is said to have been found untorn even in complete fractures. As a rule it remains uninjured over a simple

fissure. Blood will be found extravasated also in the medullary canal mixed up with the fat.

The *Period of Inflammation and Exudation.*—The first change observed after the injury are the ordinary signs of inflammation—redness, swelling, and abundant exudation. This affects the whole of the injured soft parts, so that by the third or fourth day the fracture will be found to be surrounded by a greyish-red, soft mass, not sharply defined, but infiltrating the neighbouring tissues; the torn ends of the muscles are pale in colour from the exudation between the fibres; the areolar tissue is no longer clearly recognizable, its spaces being filled by the coagulated inflammatory exudation; the outer layer of the periosteum is in like manner swollen and scarcely recognizable, and the inner layer is so soft and swollen as to be almost gelatinous; the whole membrane can be stripped from the bone with unnatural ease for some distance from the seat of fracture. In the midst of the exudation, patches of unaltered blood-clot will still be seen, but a great part of the extravasation in the immediate neighbourhood of the fracture will have already been partly discoloured.

Microscopic examination at this stage shows the usual appearances of inflammation; the vessels are distended with blood, and all the spaces of the tissues are filled with wandering white corpuscles, either closely in contact with each other, or separated by a small quantity of homogeneous or fibrinous intercellular substance.

In the medulla the fat has disappeared from the immediate neighbourhood of the injury, and its place is taken by an exudation similar to that lying externally.

The growth of the soft provisional callus.—During this stage the excess of the early inflammatory exudation and the remainder of the blood-clot in the neighbourhood of the injury is absorbed, and there is gradually developed round the ends of the broken bone a fusiform mass, holding them together with some degree of firmness. At first this is soft, almost jelly-like, and homogeneous in appearance, and the ragged ends of the torn periosteum become lost in it. It then gradually increases in firmness, till at last it becomes of cartilaginous density, and in animals, becomes actually converted into cartilage. The microscope shows, during this stage, that the soft mass at first formed presents the ordinary appearances of granulation-tissue in the greater part of its extent; near the surface muscular fibres or bands of fibrous tissue may be found mixed with it, showing that it is not formed solely from the periosteum, but also from the surrounding parts. Close to the bone, however, from a very early period, about the third or fourth day, cells are found of larger size than those of ordinary granulation-tissue, having one or more nuclei, surrounded by a finely granular protoplasm; they are usually oval or spindle-shaped, or sometimes angular in form, thus presenting the characters of osteoblasts. As the callus increases in density the superficial parts of it undergo the ordinary changes of the development of granulation-tissue into fibrous tissue, and thus a layer is formed which afterwards becomes the fibrous part of the new periosteum covering the callus. In animals the greater part of the soft callus becomes developed into cartilage. A homogeneous ground substance forms between the cells, which now assume a sharply defined outline. The cartilage-formation is most perfect in the immediate neighbourhood of the broken ends of the bone; at the point most removed from the fracture, where

the new tissue is exposed to the smallest degree of disturbance by any accidental movement, lime-salts are deposited in the ground-substance amongst the osteoblasts without any true development of cartilage. Similar changes occur in the medullary canal, true cartilage being formed only at the immediate seat of fracture.

The complete ossification of the provisional callus.—The formation of new bone in the soft callus commences by the appearance of yellowish-white points or streaks appearing first in the part in contact with the bone at the point furthest removed from the seat of fracture. These points and streaks gradually increase till the callus becomes converted into soft spongy bone, containing wide cancellous spaces filled with red vascular medullary tissue. The ossification gradually spreads from above and below, towards the seat of fracture, till the process of conversion of the soft callus into bone is complete. The changes that occur within the medullary canal are of the same character. The new bone thus formed differs from normal compact tissue in being softer, more vascular and spongy. If a longitudinal section of the bone be made, it will be seen that the callus is covered by a thick vascular periosteum which can be stripped off without difficulty; it leaves the surface of the callus rough and spongy, with wide Haversian canals containing some red medullary tissue. The trabeculæ of the callus are set at right angles, or nearly so, to the surface of the compact bone beneath, from which the callus can at first be separated without difficulty. If this be done, however, the surface of the compact bone is seen to be slightly more spongy than natural, the openings of the Haversian canals being enlarged.

Fig. 175. — Fracture of Tibia with provisional callus.

Microscopic observation shows that when ossification of the callus takes place without the previous formation of cartilage, the cells most distant from a vessel assume the angular form of osteoblasts, lime-salts are deposited in the ground-substance between them, and true bone is developed. On the surface of this lamella of bone a layer of osteoblasts remains, by the activity of which the process is continued, and the space around the vessel gradually narrowed, till it is reduced to the form of a Haversian canal. If cartilage have previously formed, new vessels penetrate it, both from the bone beneath and from the periosteum, as a preliminary step towards ossification. The ossification of the callus in the medullary canal proceeds in the same way.

The *development and ossification of the intermediate* or *definitive callus*, proceed in the same way as in the formation of the provisional callus. The time at which it forms will depend greatly upon the perfection of the apposition, and the immobility attained by treatment. It is evident that no process of repair can take place between two surfaces of compact bone so long as they are grinding against each other at each movement of the limb. The first change observed is an enlargement of the Haversian canals. This is effected by the growth of new cells within the canal. These, according to some pathologists, are migratory white corpuscles, but according to others, cells developed from the medullary tissue in the Haversian canals. Be this as it may, the bony wall of the canal is absorbed before the new cells. As

soon as the opposing fragments are put at perfect rest the new cells sprout out from the canals on each side and fill the space. Ossification then proceeds in the new tissue thus formed, but without the previous formation of cartilage.

The *absorption of the provisional callus* forms the final stage of repair of a fracture. At first the porous callus becomes more compact, harder, and less vascular, and as the change takes place it becomes more intimately connected with the old bone which it now closely resembles in structure. This hardening is most marked in the deeper layers in contact with the old bone, and as it takes place absorption goes on in the part next the periosteum, which at the same time becomes smooth and even. In the medullary canal the new bone becomes more and more cancellous in its structure, and finally there may be complete restoration of the medullary canal, though this is undoubtedly rare. The absorption of the callus is never complete, some thickening permanently remaining at the seat of fracture, however perfect the apposition and rest may have been. Any irregular points of bone, that may have been projecting after the union, become gradually absorbed and rounded off. These final processes are not completed for a year or more after the fracture has been united.

Thus, it will be seen that the process is analogous in every way to repair of a wound by the first intention. First there is the exudation resulting from the simple traumatic inflammation, the effect of the mechanical violence; then follows the development of a vascular tissue, composed of indifferent embryonic cells or granulation-tissue; this develops into the form of connective tissue natural to the part; and finally the obliteration of vessels and consolidation of the cicatricial tissue occurs, as in the formation of a scar in the soft parts. The same questions are in dispute in the union of fractured bones as in the repair of other tissue, namely, what part is taken by the white corpuscles in the formation of the new tissue, and what is the exact fate of the blood-clot? One point with regard to the blood-clot it is important to remember, as it might be of importance in medico-legal enquiries. Although it completely disappears from the immediate neighbourhood of the fracture at an early period, layers of dark coagulum may often be found beneath the superficial fascia for four weeks or more after the accident.

The process above described, although essentially the same in man, differs much in its details. The process is slower, and the formation of callus is as a rule less abundant. If the fracture be well treated, it may in fact be almost wanting, union apparently taking place by the direct, or almost direct, formation of the definitive or intermediate callus. Histologically, the most important difference is that in man, as a rule, the formation of cartilage does not occur. It has, however, been met with in the union of bones in children, and it is always found in a uniting rib, but even here it is seldom pure, the ground substance being usually fibrous. Possibly the formation of cartilage in the rib may be due to the impossibility of fixing the injured bone, owing to the movements of respiration. In animals, the purest cartilage is found exactly opposite the seat of fracture, where there will necessarily be the greatest disturbance from movement.

Modification of Union of simple fracture.—The amount of callus formed in the union of a bone varies considerably. It is greater in children than in adults. In transverse fractures which are kept steadily in apposition, but little callus is formed; externally it may be scarcely perceptible, and

internally it may be merely a thin tube not obliterating the medullary canal. It is greater in those bones and those parts of a bone which are thickly covered by soft parts, being formed as before stated not only from the periosteum and bone, but also from the surrounding tissues. The influence of the neighbouring soft parts in determining the formation of new bone is well marked in the tibia. In a fracture of this bone we find that, at the anterior and inner part, which is thinly covered, union takes place by the direct formation of intermediate callus ; but at the posterior and outer side, where there is a thick envelopment of tissue, a large mass of provisional callus will often be found, filling up even the interosseous space. Occasionally we find that the inflammation set up around a fracture has extended to a neighbouring bone, and caused a formation of new bone upon it. There are specimens of bones of the fore-arm and leg in the University College Museum illustrating this point.

The formation of callus is also greatly influenced by the nature of the fracture. If the fracture be comminuted and the fragments displaced, there may be an abundant formation round the splintered fragments welding them together. If there be great displacement, one fragment riding far over the other, the callus will be found chiefly between the two fragments, connecting them together by a bridge of bone. So also, in cases of great angular deformity, when the final process of partial absorption and moulding of the new bone has taken place, a larger amount is left in the angle, partly filling it up. and forming a sort of buttress to strengthen the bent bone. Lastly, the amount of callus is influenced very greatly by treatment ; the more perfectly rest is maintained, the smaller will be the amount of callus formed.

Union of a separated Epiphysis takes place in the same way as union of a transverse fracture. It almost invariably causes complete ossification of the epiphysial cartilage and consequent arrest of growth from that end of the bone.

TREATMENT OF FRACTURE.

The treatment of a simple fracture uncomplicated in any way is a very simple business. All that the Surgeon has to do is to place the fragments in proper position and in good apposition, and to retain them there, and to attend to the general health of the patient on ordinary principles. Nature does the rest. In no way can the Surgeon accelerate the processes or improve upon them. By meddlesome treatment he may do much to retard and to disturb them.

Constitutional Treatment in simple fractures requires but a very few words of explanation. As a rule, the general habits of life should be interfered with as little as possible. In uncomplicated fractures of the upper extremities, more especially in the young, rest for a few days in bed is all that is needed. The patient may then be allowed to move about moderately with the limb supported on proper apparatus. In fractures of the lower extremities more lengthened rest is needed. In these cases the diet may be somewhat reduced, and aperients given with advantage for the first week or ten days. After this the usual habits of life in these respects should be resumed.

In old persons the enforced confinement to bed and the sudden interruption of the ordinary habits of life, as well as the shock to the system, are apt to

exercise an injurious and sometimes a fatal effect. In these cases there are two dangers to apprehend, viz., hypostatic congestion of the lungs and the formation of bed-sores. Both are avoided by propping the patient up in bed, the use of water or air cushions, and change of posture as far as practicable. It is necessary to see that the bed is very smooth and firm—without creases; that all crumbs be swept away daily; and that scrupulous attention be paid to cleanliness after the use of the bed-pan. Good diet and a fair allowance of stimulants are needed in these cases. The early use of the starched or plaster-of-Paris-bandage is of great service in enabling the patient to get up sooner than could otherwise be done.

In all cases of simple fracture of the lower extremities, the sooner the patient is got up and about on crutches the better. Some patients speedily learn to use these instruments, others never get accustomed to their use. In the latter case, a wheel-chair should be substituted for them.

Surgical Treatment of Simple Fracture.—In conducting the treatment of a fracture, the object of the Surgeon should be not only to obtain a sound and strong limb, but one that presents as little deformity and trace of former injury as possible. In order to accomplish this, the broken ends of the bone must be brought into as perfect apposition as possible, the recurrence of displacement must be prevented, and the local and constitutional condition of the patient properly attended to.

It frequently happens that a Surgeon is called to a case of fracture, either immediately after the accident before the patient has been moved and without being informed of the nature of the case. It is then his duty to superintend the moving of the patient, and to see that it is done as far as possible painlessly and without increasing the injury to the soft parts by needless movement of the limb. For this purpose temporary splints may be applied outside the patient's clothes, and secured, in the absence of bandages, by pocket-handkerchiefs tied round the limb. A couple of walking-sticks or umbrellas, or the handle of a broom, may thus be applied to the thigh or leg; or a splint cut from the cover of a book to the arm. Newspapers folded several times till they form a mass of sufficient stiffness make excellent temporary splints.

If the patient have been already moved and is upon a bed, the limb must be placed in such a position as to give the greatest general relaxation of the muscles. Thus the lower limb must be flexed and placed on its outer side with a thin pillow under the knee. In fractures of the upper limb the arm should lie by the side with the forearm flexed. The patient thus being made as comfortable as possible, the necessary arrangements can be made for the definite treatment of the fracture. If the case be one of severe fracture of the upper extremity, or of any kind in the lower limbs, the Surgeon must see that the bed, on which the patient may have to remain for some weeks, is properly prepared, by being made hard, flat, and firm, and, if possible, covered with a horse-hair-mattress. The Surgeon must then superintend the removal of the patient's clothes, having them ripped along the seams, so that they may be taken off with as little disturbance as possible to the injured part. He next proceeds to the examination of the broken limb, using every possible gentleness consistent with acquiring a proper knowledge of the fracture. After he has satisfied himself upon this point, the limb should be again placed in a comfortable position, until any necessary apparatus has been prepared.

Reduction.—When all has been got ready, the reduction of the fracture, or the bringing the fragments into proper apposition, must be proceeded with. This should, if possible, always be done *at once*, not only lest any displacement that exists may continue permanently—the muscles, after a few days, becoming shortened, rigid, and unyielding, not allowing reduction to be effected without the employment of much force—but also with the view of preventing irritation and mischief to the limb, by the projection of the sharp and jagged ends of bone into the soft structures. A great deal of time is sometimes lost, and much unnecessary pain inflicted upon the patient, and great irritation set up in the limb, by the Surgeon leaving the fracture unreduced on a pillow for several days, and applying evaporating lotions to take down the swelling and avert the threatened inflammation, which are consequences of the non-reduction of the broken bone. The application of cold lotions, irrigation, &c., in compound or even in simple fractures is decidedly injurious. It lowers the vitality of the part, retards union, and occasions œdema. By early reduction we may sometimes prevent a sharp fragment from perforating the skin, and thus rendering a simple fracture compound, or lacerating muscles and nerves, inducing perhaps traumatic delirium and certainly undue local inflammatory and spasmodic action.

The chief cause of displacement in fractures has already been stated to be muscular contraction; hence, in effecting reduction of a fracture and in removing the displacement, our principal difficulty is the action of the muscles of the part. This usually may be counteracted, by properly relaxing them by position; so soon as this is done, the bony fragments will naturally fall into place; but no amount of extension and counter-extension can bring them into position, much less retain them there, unless all muscular influence be removed. In ordinary fractures, no force is necessary or should ever be employed for accomplishing this; but attention to the attachment of the muscles of the limb and proper relaxation of them is all that is required. In impacted fractures it is occasionally necessary to use force in order to disentangle the fragments, but this is the only form of fracture in which its employment is justifiable. In effecting the reduction, not only must the length of the limb be restored, but its natural curves must not be obliterated by making it too straight. Muscular action being the chief, and, in most cases, the only obstacle to reduction, it would seem the most natural way to overcome the difficulty to administer an anæsthetic, which would at the same time save the patient the severe pain usually attending the setting of a broken bone. It is a rule, however, in reducing a simple fracture to avoid anæsthetics. We never can tell beforehand whether the patient will become quietly insensible, or whether insensibility will be preceded by a violent fit of struggling, during which there would be the greatest possible danger of a simple fracture being made compound. If from any reason, such as the nervousness of the patient, or the difficulty in overcoming the muscular action by position, it becomes necessary to give an anæsthetic, there must be plenty of assistants at hand to restrain the patient if necessary. The limb must then be put in the best position possible, and firmly supported by splints rather lightly applied. When everything is ready the injured limb must be confided to the charge of one assistant only. If two attempt to hold a leg, one by the foot and the other by the knee, they may cause the very mischief it is intended to prevent.

Prevention of Return of Displacement.—After the reduction has been

accomplished, means must be taken to prevent the return of the displacement. We have already seen that the three great causes of displacement in a fracture are, external violence, the weight of the limb, and the contraction of the muscles. In the upper limb the weight is supported during the treatment of the fracture when necessary by slings or properly applied bandages. In the lower limb the chief displacement due to the weight of the limb is rotation outwards, this is prevented by lateral splints. The displacements due to muscular action are far the most troublesome, for, if the parts be left to themselves, the involuntary movement of the patient will be certain to bring about a return of the faulty position. In many cases it is exceedingly difficult, for the first few days, to keep the ends of the bone in place, in consequence of spasmodic movements of the muscles of the limb, or of restlessness on the part of the patient. About this, however, the Surgeon need not be anxious, as no union takes place for the first week or ten days ; at the expiration of that time the muscles will have probably lost their irritability, and the patient have become accustomed to his position, so that with a little patience, or by varying the apparatus and the position of the limb, good apposition may be maintained.

The displacements due to muscular action are overcome in two ways, which may be used together or separately—**relaxation and extension.** The principle of **relaxation** was first laid down by Percival Pott. It consists merely in placing the limb in such a position as to relax the chief disturbing muscles to the greatest possible extent. There is no doubt it is of the greatest value in the treatment of the majority of broken bones. **Extension** consists in applying an apparatus by which the lower fragment is forcibly pulled in the direction opposite to that in which the muscles are displacing it. In order to apply it efficiently, counter-extension must be made upon some part of the body above the fracture. Extension is usually made by the Surgeon pulling forcibly on the lower fragment, the apparatus being used merely to retain the limb in the position in which he has placed it ; in some cases, however, elastic extension is applied by means of india-rubber. Considering the great power of the muscles, it is evident that in many parts it would be almost impossible to apply sufficient force to overcome the displacement they give rise to. It seems, however, that long-continued and steady extension gradually tires out the muscles in such a way that they yield before it. Extension to be efficient should therefore be constant. Extension is of course most useful against longitudinal displacement, but it also aids in the reduction of angular deformity. As types of these two modes of treatment, the treatment of fracture of the thigh by the double inclined plane, and by the long splint, may be referred to.

A third method of overcoming muscular action has been suggested: **the division of the tendons** of some of the stronger muscles inserted into the lower fragment. This, however, can very rarely be necessary, and in those cases in which I have done it, or seen it done, no material benefit has resulted.

The displacement due to the external violence which caused the fracture is overcome at the time of reduction ; any further displacement from a similar cause is prevented by the application of the various splints about to be described.

The return of displacement is prevented, and the proper shape and length of the limb are maintained, by means of *bandages, splints,* and *special apparatus* of various kinds. In applying these care should be taken not to exert any

undue pressure on the limb. Pads and compresses of all kinds intended to force the bone into position by pressing on the projecting fragment, should, if possible, be avoided; they do no good that cannot be effected by proper position, and even occasion serious mischief by inducing sloughing of the integuments, over which they are applied. A screw-apparatus has been invented with this view, but nothing can be more unsurgical and unscientific than such barbarous contrivances.

The **Bandages** used in the application of splints and other apparatus to fractures should be the ordinary grey calico rollers, about two to three inches in width, and eight yards in length. In applying them, especial care must be taken that the turns press evenly upon every part, and that the bandage be not applied too tightly in the first instance. No bandage should be applied *under* the splints, more particularly at the flexures of joints, and care must be taken that the limb be not bent, or its position otherwise materially altered, after bandages have been applied. A bandage *under* the splint is not only useless, but highly dangerous, by inducing risk of strangulation. No bandage should be applied to the part of the limb that is the seat of fracture. The part below the fracture may be sometimes advantageously bandaged, in order to prevent œdema; thus, in fracture of the humerus, the forearm may be bandaged with this view, but no turns of the roller should be brought above the elbow. This point of practice I consider most important, as the application of a bandage to the immediate seat of fracture not only causes great pain and disturbance of the limb, but danger of gangrene. When once a fractured limb has been "put up," the less it is disturbed the better. No good can possibly come, but a great deal of pain must necessarily result to the patient, from meddling with it. The Surgeon should always bear in mind that, in the treatment of a fractured bone, he can do absolutely nothing to promote its union, beyond placing it in a good and easy position. Nature—the natural reparative action of the body—solders the bone together; and the less the Surgeon interferes with the natural processes of repair, the more satisfactorily will union be accomplished. But it is requisite to examine the limb from time to time during the treatment, and especially about the second or third week, when union is commencing, in order, if necessary, to correct displacement. In the earlier stages, supervision is necessary lest the bandage be too tight; and, if the patient complain of any pain or numbness, or if the extreme parts look blue and feel cold, the bandage must be immediately removed; for, though the apparatus have not been applied tightly, swelling of the limb may come on from various causes, to such an extent as to produce strangulation and consequent gangrene of it, as I have seen happen in at least three instances, the limb requiring amputation in each case (Fig. 181). It is remarkable, that the whole of a limb will fall into a state of gangrene in these circumstances, with but little pain, and often with very slight constitutional disturbance, the parts having their sensibility deadened by the gradual congestion and infiltration of the tissues. When such an unfortunate accident happens, recourse must be had to immediate amputation. Before applying the apparatus in a case of fracture, and as often as it is taken off, it is a good plan to sponge the limb with warm soap and water, which prevents the itching that otherwise occurs and is sometimes very troublesome.

Splints of various kinds are used in cases of fracture. Tin, wire, zinc, or thin sheet-iron, wood, leather, "poroplastic material," and gutta percha, are

the materials usually employed. For some kinds of fracture, special, and often very complicated apparatus, is very generally used; but the Surgeon should never confine himself to one material, or one exclusive mode of treating these injuries, as in different cases special advantages may be obtained from different kinds of splints. Wood and tin are employed principally in the lower extremity, where great strength is required to counteract the weight of the limb and the action of its muscles; and care must be taken to pad very thoroughly splints made of these materials. Leather, gutta-percha, pasteboard, and poroplastic splints are more commonly useful in fractures of the upper extremity, though they may not unfrequently be employed with advantage in those of the lower limbs. In applying them, a pattern should first be cut out in brown paper, of the proper size and shape; the material must then be softened by being well soaked in hot water, and moulded on to the part whilst soft: as soon as it has taken the proper shape, it should, if gutta-percha be used, be hardened by being plunged into cold water; pasteboard, leather, or poroplastic splints must be allowed to dry on the limb. The edges may then be feathered and the corners rounded, and the interior lined with wash-leather or lint. These splints have the advantage of great durability, cleanliness, and lightness.

The material of which the splint is composed is of less consequence than its mode of application. There are three points that require special attention in this respect:—1, that when the splint is flat it should be everywhere wider than the limb, so that the limb may lie on the splint, and not the splint rest upon the limb; 2, that it should embrace securely and fix steadily the two joints connected with the fractured bone; if the thigh, the hip and knee; if the leg, the knee and ankle; and 3, that it be well padded beyond the edges. From want of attention to these points of practice much trouble is often occasioned in keeping the fragments in steady apposition, and much deformity may result. It is impossible to keep the fragments perfectly immobile, and in close and accurate apposition, unless these very important points be attended to.

Special Apparatus should be employed as little as possible in the treatment of fractures. It is scarcely ever necessary in simple fractures, and is far more cumbersome and costly than the means above indicated, which are all that can be required. I have no hesitation in saying, that a Surgeon of ordinary ingenuity and mechanical skill may be fully prepared to treat successfully every fracture to which he can be called, by having at hand a smooth deal plank half an inch in thickness, and a sheet of gutta-percha, undressed sole-leather, pasteboard, "poroplastic material," perforated zinc, or thin sheet-iron, to cut into splints as required.

To the means above described, some form of rigid apparatus, moulded to the limb, forms an invaluable addition. Although various plans for stiffening and fixing bandages in cases of fracture had been employed at various times, it was not till about thirty years ago that their full value became recognized, chiefly through the practice and writings of Baron Seutin. Since that time a variety of substances, as gum and chalk, glue, paraffin, tripolith, and water-glass, have been recommended for the purpose of stiffening bandages, but the two which are practically most useful, and have longest maintained their reputation, are the starched bandage and the plaster-of-Paris-bandage. These represent two different types of fixed apparatus. The starched bandage is applied over a mass of cotton-wool, which is firmly compressed during the

application of the apparatus, and thus exerts a gentle uniform elastic pressure, holding the fragments in position. As swelling subsides, it is removed, its edges pared, fresh cotton-wool put in, and it is then re-applied. The plaster of Paris bandage takes an actual cast of the injured limb; it is not intended to exert any pressure—in fact, if applied in such a way as to do so, it is a dangerous application, and it cannot be removed and re-applied.

The Starched Bandage.—The following is the mode of applying this apparatus that is adopted at the University College Hospital, and which will be found to answer well. The whole limb is enveloped, as recommended by

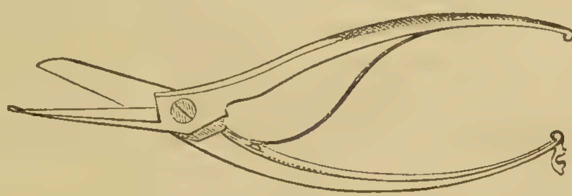


Fig. 176.—Seutin's Pliers.

Burggraeve, of Ghent, in a thick layer of cotton-wadding, thickest along and over the osseous prominences; this, being elastic, accommodates itself to the subsequent diminution in size of the limb, and keeps up more equable pressure.

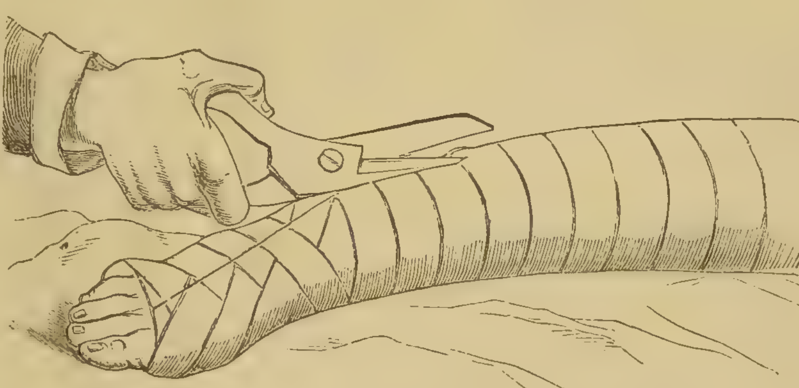


Fig. 177.—Application of Seutin's Pliers to Starched Bandage.

Over the cotton-wadding are laid splints of thick and coarse pasteboard soaked in thin starch, properly shaped to fit the limb. The pasteboard should be soft, not milled, and be doubled and torn down, *not* cut, as in this way the edges are not left sharp. If much strength be not required, as in children, or in some fractures of the upper extremity, a few slips of brown paper, well starched, may be substituted for the pasteboard. A bandage saturated with thick starch is now firmly applied; and lastly, this is covered by another dry roller, the inner sides of the turns of which may be starched as it is laid on.

The bandages must be applied with sufficient force to compress the mass of cotton-wool surrounding the limb. There is no danger of constriction if enough wool be used. No bandage must on any account be applied beneath the pasteboard splints. Both the pasteboard splints and the starched bandage should always include the two joints above and below the fracture, so that complete immobility of the fragments may be secured: the hip and knee when the thigh is broken; the knee and ankle when the leg is fractured.

During the application of this apparatus, extension must be kept up by an assistant, so as to hold the fracture in position; and, until the starch is thoroughly dried, which usually takes from thirty to fifty hours, a wooden splint may, if necessary, be applied to the limb, so as to keep it to its proper length and shape. The drying of the starch may be hastened by the application of hot bottles to the apparatus. After the bandages have become quite dry, the patient may be allowed to move about on crutches, taking care, of course, to keep the injured limb well slung up, and not to bear upon it, or to jar it against the ground (Fig. 179). In the course of about three or four days after its application, the apparatus will usually be found to have loosened somewhat, the limb appearing to shrink within it. In these circumstances, it becomes necessary to cut it up with a pair of Seutin's pliers, such as are represented in Fig. 176, or a pair of French vine-dresser's scissors which are perhaps more durable. This section must be made up the front of the limb, care being

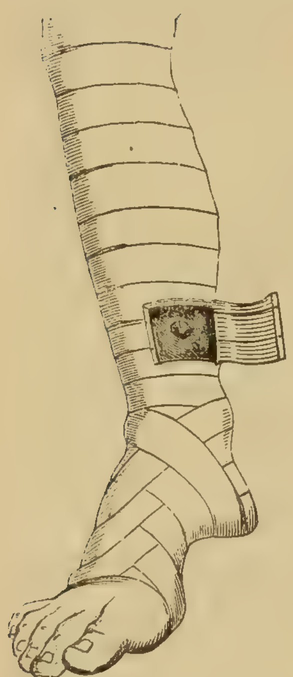


Fig. 178.— Starched Bandage: Trap left for Dressing Wound.

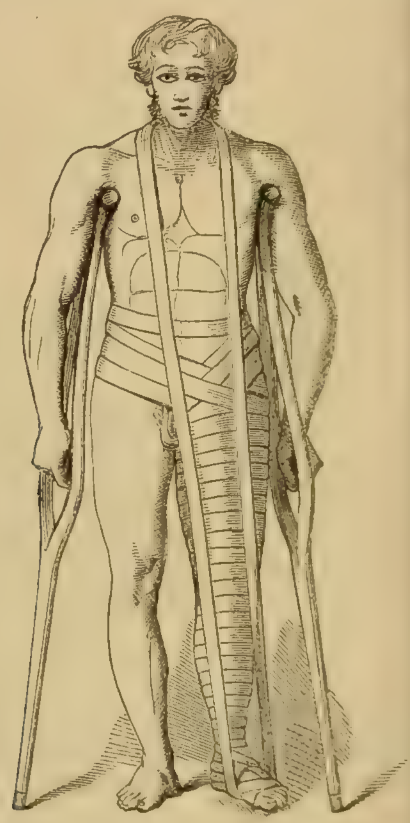


Fig. 179.—Starched Bandage applied to Fractured Thigh.

taken not to injure the skin in so doing. If the fracture is so far consolidated that the limb can be handled without fear of displacing the fragments, the splint may be completely removed, and its edges pared, about three-quarters of an inch being taken from each. The cotton-wool is then cleaned out from its inside, a fresh layer is wrapped round the limb, and the apparatus re-applied by means of an unstarched roller or tapes. If the fracture be too recent to allow of this, the edges must be pared without removing the splint from the limb, and changing the cotton-wool must be deferred to a later period. If the

fracture be compound, a trap may be cut in the apparatus opposite the seat of injury, through which the wound may be dressed (Fig. 178).

The advantages of the starched bandage in the treatment of fractures, as well as in many other injuries and diseases, consist in its taking the shape of the limb accurately and readily, and maintaining it by its solidity; in its being light, inexpensive, and easily applied, with materials that are always at hand. It secures complete immobility of the limb in the position in which it dries. The joints in the neighbourhood of the fractured bone are securely fixed, and the perfect adaptation or moulding of the apparatus to the inequalities of the limb prevents all movement. Thus it maintains accurately not only the length but the normal curves of the limb. From its lightness, it possesses the very great and peculiar advantage in fractures of the lower extremity, of allowing the patient to remain up and to move about upon crutches during nearly the whole of the treatment; thus, by rendering prolonged confinement to bed unnecessary, it prevents the tendency to those injurious consequences that often result from these injuries; and, by enabling the patient to keep up his health and strength by open-air exercise, it facilitates the consolidation of the fracture. In addition to this, the patient will often be able to carry on his business during treatment. By employing the starched bandage in the way just described, I scarcely ever find it necessary to keep patients in bed with simple fractures of the leg for more than from four to seven days, thus saving much of the tediousness and danger of the treatment.

Although fully recognizing the great advantages to be obtained by treating fractures on this plan, and employing the starched bandage in almost every case that came under my care, I did not at first think that it was safe practice to have recourse to it during the early stages of fracture; until, indeed, the swelling of the limb had begun to subside. I therefore never applied it until the sixth, eighth, or tenth day, keeping the limb, until this time, properly reduced upon a splint; fearing that, if the bandage were applied at too early a period, the inflammatory turgescence of the limb might give rise to a slow strangulation of it under the apparatus. During many years, however, I employed Seutin's plan in several hundreds of fractures of all kinds, putting the limb up in the starched apparatus *immediately* after the reduction of the fracture. I found the practice a safe one, even in fractures of the thigh; so much so, that at the Hospital I for some time rarely used any other plan of treatment than the "movable-immovable" apparatus in some form, varying with the fashion of the day. The moderate pressure of the bandages, aided probably by the great evaporation from so extensive and thick a mass of wet starch, seemed to take down the swelling most effectually. Thus the patient was often able to leave his bed about the third day after the injury, when the fracture was in the leg or ankle, and about the sixth when it was the thigh that was broken.

Further experience, however, showed that the fractures to be treated in this way require selection. A simple fracture of one bone of the leg or of both bones, without comminution or marked displacement, or great extravasation of blood, may safely be put up immediately in the starched bandage or any other rigid apparatus. In more severe cases it is better to wait till the end of the first week or beginning of the second before applying the starched bandage. In fractured thighs also it is better to allow a certain degree of consolidation to take place, otherwise from the difficulty of completely fixing the hip-joint by

means of a starched bandage some return of displacement may take place. The best time for its application in these cases is about the end of the second week. Care must be taken to enclose the foot in the splint, otherwise rotatory displacement outwards may take place. By this means I have obtained the most satisfactory results in cases of fractured thigh; patients having frequently been cured without any appreciable shortening, with the preservation of the natural curve of the bone, and without confinement to bed after the second week.

In compound fractures also of the leg, and even of the thigh, I have obtained most satisfactory results from this means. In compound fractures of the leg, I have seen the patient walking about on crutches as early as the tenth or fourteenth day, the limb being securely put up in starch; and have more frequently succeeded in getting union of the wound, and consequently in converting the compound into a simple fracture, by putting up the limb in this apparatus than in any other.

Plaster of Paris may be used in the treatment of fractures in any one of the four following ways:—

1. The *simple plaster-bandage* is thus applied. A coarse muslin-bandage is first prepared by rubbing thoroughly into its meshes some fresh plaster. The very best plaster must be used and it must be quite fresh; if it has been exposed even for a few days in a damp place it will be practically useless. The bandage is then loosely rolled up, a little more plaster being sprinkled between its turns as this is done. The necessary number of bandages having been got ready, the limb must be prepared. This is done in various ways. Formerly at University College Hospital we used merely to grease the limb and apply the plaster directly to the skin. This had the disadvantage of being difficult to remove. The better plan is to apply a dry flannel-bandage smoothly to the limb. The bandage must be made of elastic Welsh flannel and not be drawn more tightly than is necessary to prevent creasing, otherwise it might cause constriction of the limb. A prepared plaster-bandage is then placed, end upwards, in a basin of water deep enough to cover it completely. It is then taken out and squeezed to get rid of the excess of water and smoothly rolled over the flannel. The bandage must on no account be pulled. It is to be laid smoothly on the limb without making reverses. In order to avoid these, it may be cut whenever required. The muslin-bandage, it must be remembered, is used merely as a convenient means of applying the plaster and to give toughness to it when it is set; a plaster-bandage must on no account be used to exert pressure, or when it sets it may cause serious constriction of the limb. As the bandage is applied it must be rubbed with the hands to squeeze out any air that may have got between the turns, and if necessary, some dry plaster may be sprinkled over it at intervals and rubbed in with the hand wetted with water. If it be thought necessary to strengthen the apparatus at any point, it may be done by laying on slips of the plaster bandage, which must be secured by a final circular turn; or strips of thin tin-plate or perforated zinc may be applied between the layers of bandage. In an ordinary case about three layers of bandage will be required. Some Surgeons prefer to use cotton wool instead of the flannel; this however necessitates pulling the bandage which is never a safe proceeding with plaster. Moreover, cotton-wool after a few days becomes packed together inside the plaster-case which no longer fits accurately. If a mass of cotton-wool be

made to surround the limb it is better to apply either the starched bandage and paste-board splints or the silicate of soda bandage, both of which can be cut up and removed and repacked without destroying the splint.

Good plaster hardens in the course of about eight minutes, and, as it dries forms a solid, hard, and light casing to the limb, affording excellent support to the fracture. The setting of the plaster may be retarded by the addition to it of solution of borax. Thus a solution of 1 part to 12 of the water used will retard the setting fifteen minutes ; and 1 to 8 will retard it fifty minutes, and so on. The plaster-bandage possesses the advantage over the starched apparatus of being lighter and less cumbersome, and especially of drying and hardening very quickly, so that not only can the limb be easily held in position by the Surgeon till the plaster is set, but the patient can be immediately moved to any distance after the setting of the fracture.

The plaster-of-Paris-bandage may be applied to any fracture after the swelling has subsided, and it may be put on immediately in all cases in which, from the nature of the injury, but little swelling is to be expected, such as fracture of the metatarsal or metacarpal bones, or fracture of one bone of the leg. If there is already much swelling, it is better not to apply the plaster till this has subsided, otherwise the splint soon becomes loose as the swelling subsides. After its application the exposed parts of the fingers or toes must be carefully watched, and if they should become blue or cold the apparatus must be at once removed.

2. Neudörfer is a strong advocate for the employment of the plaster-of-Paris-bandage. He recommends that it should be applied immediately (on this he lays great stress), in the following way. Compresses of linen, or of lint, are dipped in plaster of Paris of the consistence of a common poultice. These are then placed longitudinally on the limb, first on the upper, then on the under part. A few turns of a bandage keep them *in situ* till the plaster is set. To prevent the contiguous edges from adhering, they are slightly greased, or a slip of greased lint is put between them. He sometimes uses pieces of thin wood, like veneer, lined with cotton-wool, next the skin ; over these the bandage, saturated with the plaster, is applied by circular turns in the usual way.

3. The method of applying the plaster-apparatus, as practised in the Bavarian army during the Franco-German War, is as follows. Two pieces of flannel, twenty inches broad, are stitched together down the middle for the length of the leg ; and beyond this both are cut through in the same line for the length of the foot. The flannel is placed under the limb, so that the seam reaches from the ham to the heel. The sides of the inner piece are brought together over the leg, and fixed in front, and along the sole, by hare-lip pins (bent at a right angle, so that they may be easily extracted afterwards), and thus a closely fitting stocking is formed. The sides of the outer piece are then brought forwards and cut, so that each may overlap the middle line of the leg and sole by three-quarters of an inch. The limb is then laid on one side : and while the outer piece of flannel is held back, a layer of plaster of Paris of the consistence of thick cream is spread evenly, to the thickness of half an inch, over the inner piece, and made to pass quite to the seam behind, and the line of junction of the sides of the inner piece in front. The outer piece is pressed over this before it sets, and should just reach the middle line in front and along the sole. When this has set, the limb is turned over, and the process is repeated on the

other side. The pins may now be removed. The seam serves as a hinge; and when the whole has set, the splint may be taken off, the edges of the plaster trimmed, and those of the inner piece of flannel cut so as to leave sufficient to turn over and stitch down on the outer piece. The splint is then re-adjusted and fixed by a bandage (Fig. 180).

4. Another mode of the application of plaster, which has been recommended by Croft, of St. Thomas's Hospital, will be found very useful. Some common house-flannel or old blanket is cut into the form of lateral splints, and of such size as almost to meet round the limb. Two of these must be cut for each side of the limb. The one which is to lie next the skin is then placed upon a table, with its inner side downwards; the other is well soaked in plaster of Paris and water of the consistence of thick cream, and immediately applied to it. The two are then taken up together and placed upon the limb; those for the opposite side having been prepared in the same way are quickly applied, and the whole surrounded by a muslin-bandage. The limb is to be held in

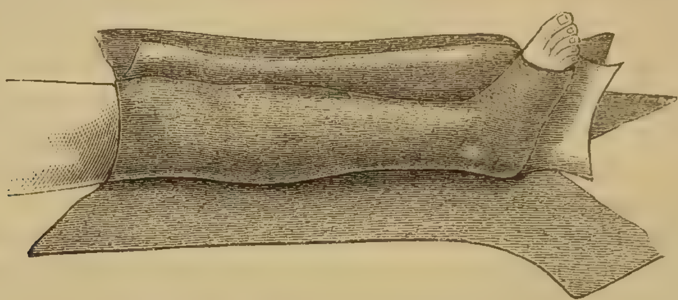


Fig. 180.—Bavarian Plaster Splint.

position while the plaster sets. When all is solid the muslin-bandage can be cut down the front of the limb, and the apparatus taken off whenever it is desirable to examine the fracture.

In all cases in which the plaster-bandage is used, there is danger of unsafe constriction of the limb after the setting of the plaster, either in consequence of the apparatus having been applied too tightly, or of the inner bandage, which has been directly applied to the limb, becoming tightened by the swelling of the member within it. Hence great care must be taken for several days after the application of the apparatus, to watch the limb carefully, and if signs of over constriction come on, such as pain, coldness, numbness, and œdema of the extremities, whether toes or fingers, immediately to cut it up, re-adjust, or remove it. No time should be lost in doing this, as the limb may have become gangrenous in patches, with little suffering to the patient or constitutional disturbance.

The Silicate-of-Soda- or Water-glass-Bandage is another very useful form of rigid apparatus. The materials required are a solution of silicate of soda of the consistence of syrup, which can be purchased ready prepared, and keeps well in a stoppered bottle, and some thin bandages. The bandages are to be thoroughly soaked by being drawn through a sufficient quantity of the solution in the bottom of a basin, and then rolled up again. A thick padding of cotton wool is then put round the limb, and the silicate-bandage applied directly upon it. No pasteboard-splints are used, and about four or five layers of bandage will be required. It dries in from 12 to 24 hours, and makes

a clean, firm, light case, which can be cut up and treated like a starched bandage.

In the treatment of ordinary simple fractures of the shafts of long bones, the following are the chief points that require attention :

1. To effect reduction at once, and with as little disturbance of the limb as possible.

2. Not to apply any roller to the part of the limb in which the fracture is situated, nor under the apparatus.

3. To line, pad, or wad the apparatus thickly.

4. To include and fix in the apparatus the two joints connected with the injured bone.

5. To disturb the apparatus as seldom as possible.

6. To use starched pasteboard- or plaster-apparatus, when practicable, in preference to any more special form of appliance.

Accidents and Complications during Treatment.—Various accidents and complications are liable to occur during the treatment of a fracture ; some of these are general and others special. Amongst the more common complications to which these injuries are liable, in common with all others, are tetanus and erysipelas, but these rarely complicate simple fracture. They require no further notice here.

Traumatic Delirium, or **Delirium Tremens**, is by no means an uncommon complication, and is always serious. The general treatment has been already given (p. 291). Locally, as soon as the symptoms show themselves, the fracture must be firmly supported by splints or by a starched or plaster-of-Paris-bandage, and the injured limb must be slung from a cradle. It must on no account be tied to the bed. This, as a rule, fixes only the lower fragment, while the upper works about during the struggles of the patient, and may cause the most serious mischief.

Fat-Embolism.—If the lungs of a patient who has died shortly after a severe accident crushing one or more bones, be examined microscopically, after staining with osmic acid, a certain number of the capillaries, and perhaps some of the terminal arteries, may be found plugged with liquid fat. The appearances are very characteristic, the fat being stained black by the osmic acid ; and it is easy to recognize the plugs in tortuous capillaries surrounding the air vesicles or in the small branching arterioles. If the remaining organs be examined, similar embolic plugs may be found in all parts of the body and in the nervous centres. In the kidney the loops of vessels in the Malpighian vessels are frequently found distended with fat. The subject of fat-embolism has been fully examined by Zenker, Busch, Bergmann, Czerny, Flournoy, Déjérine, Scriba, Hamilton, and many others, and the following conclusions have been arrived at. If liquid fat or oil be in any way set free amongst the tissues it may find its way into the circulation either by means of the lymphatics or by the veins. If injected into the healthy subcutaneous tissue it enters the circulation more slowly than from the pleura or peritoneum. Pressure favours the process ; thus, if the fat of the medulla of a long bone be broken down and a laminaria digitata tent inserted, fat-embolism is speedily induced. In many surgical injuries we have the conditions necessary for fat-embolism. In fractures crushing the medulla of a bone a large number of the fat cells of the marrow are broken up and the liquid fat set free ; and the same may happen in violent contusions of the subcutaneous tissue in fat subjects,

and in contusion or laceration of a fatty liver. At the same time the pressure of the extravasation of blood and the inflammatory exudation accompanying these injuries favours the entrance of the fat into the circulation. The fat-cells are in like manner broken up in acute inflammation of the marrow of a bone, and in many diffuse gangrenous inflammations of the subcutaneous areolar tissue, and in all these conditions fat-embolism has been met with.

Fat-embolism as a complication of simple fracture may occur within the first twenty-four hours, as the direct effect of the injury, or on the second or third day as the result of the inflammatory exudation pressing on the injured adipose tissue. The symptoms caused by it are somewhat doubtful. Riedel and Scriba state that the fat is eliminated by the kidneys, and will, in a very large proportion of all fractures of long bones, be found microscopically in the urine about the third or fourth day. At a later period, from the tenth to the fourteenth day, it is often met with again, which Scriba attributes to the dislodgment of the embolisms from the lungs and other viscera and their elimination by the kidneys. A trace of albumen and some casts are sometimes met with at the same time. These appearances need not be accompanied by any constitutional symptoms. Should the quantity of fat which enters the circulation be very large, it is supposed to be capable of causing grave or even fatal symptoms, of which, according to Scriba, the following are the most characteristic : slight lowering of temperature, dyspnœa, occasionally slight hæmoptysis, and, in extreme cases, fatal collapse, spasms or localized paralysis, ending in coma and death. Scriba is of opinion that whenever fat-embolism proves fatal it is from obstruction to the vessels of the brain, and that the interference with the pulmonary circulation is never sufficient to cause death. That death does occur in some rare cases after simple fractures with some or all of the above-mentioned symptoms is certainly true, and that fat-embolism can be found post-mortem is equally certain ; but that it is the cause of the symptoms is still doubted by Cohnheim and many authorities, as experiments have shown that very large quantities of fat can be injected into the circulation of animals, so as to cause most extensive embolism, without being followed by death or even any serious symptoms.

In cases of septic inflammation following a compound fracture or a severe laceration of adipose tissue, the fat-embola may become impregnated with the septic poison, and thus set up inflammation wherever they lodge. The embola from subcutaneous injuries are said occasionally to give rise to hæmorrhagic infarcts around the point at which they are arrested, and in some cases to cause œdema of the lung by extensive obstruction to the circulation ; but being perfectly unirritating they never set up inflammation.

No treatment has as yet been suggested in fat-embolism.

In fractures of the lower extremity occurring in old people, there is a great tendency to **Hypostatic Pulmonary Congestion**, as a consequence of the long confinement required in the recumbent position ; these fractures often prove fatal in this way. The use of the starched bandage, by enabling the patient to move about, is the most effectual preventive of these accidents.

The treatment of the more general accidents presents nothing that need detain us here ; but those that are more special and peculiar to fractures, require consideration.

Crutch-palsy of the hands and arms may occur as the result of compression of the brachial nerves against the pad of the crutch. The whole plexus,

or only one of its component nerves, as the musculo-spiral, or ulnar, may be affected. The remedy is obvious—it consists in the discontinuance of the use of the crutch, and, if need be, the employment of electricity to the palsied muscles.

Spasm of the Muscles of the Limb, owing to the irritation produced by the fragments, is often very severe so long as the fracture is left unreduced; the sharp end of the broken bone puncturing and irritating the surrounding muscles. It is best remedied by reduction, and the maintenance of the fracture in proper position by moderate pressure with a bandage over the splints. In troublesome cases, compression of the main artery of the limb has been recommended by Broca. If the spasm be dependent upon nervous causes, full doses of opium will not unfrequently afford relief. In some cases it is of a permanent character, producing considerable displacement of the fragments. In these circumstances, division of the tendons has been recommended; but this practice appears to be an unnecessarily severe one, and may certainly most commonly be avoided by attention to the other plans of treatment which have been suggested.

Œdema of a broken limb may occur from several causes, viz., over-tight bandaging, dependent position, pressure of blood, extravasation, or inflammatory effusion. It is of no great moment in itself, but may be of consequence, as indicative of approaching gangrene. Relief may usually be afforded by loosening the bandages, and elevating the limb.

The œdema, which is often very persistent, after the cure of the fracture, is best relieved by diligent friction, douching, bandaging, and attention to position.

Considerable Extravasation of Blood is frequently met with in cases of simple fracture, causing great swelling and tension. By the continuous application of cold evaporating lotions, the collection is usually readily absorbed; and the Surgeon should never be tempted by any feeling of fluid or of fluctuation to open it, as he would thereby infallibly convert the simple into a compound fracture. In some of the cases of extensive extravasation, the limb appears to relieve itself of the serous portion of the blood effused, by the formation of large bullæ or blebs, which may be punctured, or else allowed to burst and subside, without any material inconvenience. This extravasation very rarely, indeed, runs into abscess; if it do, it must of course be opened, and treated upon anti-septic principles. If deeply effused it may lead to gangrene, by the constriction and compression which it exercises on the vessels of the limb.

Gangrene as a complication of simple fracture is a most serious mischance, and one from which it is difficult for the Surgeon to exonerate himself without blame. But he is not always in fault. It may arise from causes residing in the limb. It may be contributed to by the negligence of the patient in not drawing the Surgeon's attention to early symptoms, after having been duly warned. Gangrene of the limb (Fig. 181) may occur after simple fracture as the result (1) of tight bandaging; (2) of the swelling of the limb and compression of the vessels consequent upon extravasation of blood, or (3) of inflammatory infiltration causing strangulation within a bandage that has been at first but lightly applied. Gangrene is almost invariably the consequence of the pernicious and dangerous practice of applying a bandage *directly* to the limb under the apparatus. I have never known gangrene to occur after fracture, except where this has been done, since it is much more likely to occur in those

cases in which the fracture is treated by the unskilful application of an immovable apparatus, whether of starch, plaster of Paris, or other similar material, than where splints are used. Indeed, if the splints be well wadded, and no bandage be put on under them, it is almost impossible that so dangerous an amount of constriction can be exercised on the limb, as to interrupt the circulation through it. I believe that this accident would rarely, if ever, occur, if the Surgeon were to avoid the direct application of a bandage to the limb, however lightly, in fractures, more particularly in children. The danger of strangulation is especially great if, as happened in the case from which the accompanying cut is taken, the limb be bandaged whilst straight, and then flexed, as the bandage will then cut deeply at the flexure of the joint, and certainly destroy the vitality of the part, if not of the whole limb. The pressure of an axillary pad, used in many of the fractures of the upper extremities, may also tend to the supervention of gangrene by interfering with the return of blood through the axillary vein, and thus causing slow strangulation under the

Fig. 181.—Gangrene of Forearm and Hand from Tight Bandaging.

bandage. Hence in these cases the fingers should be left free at their tips, and examined daily. Even if no *direct* bandage have been applied, the apparatus should at once be removed, and the limb examined, whenever the patient complains, even of slight uneasiness: or, indeed, if any appearances of congestion, such as blueness, coldness, œdema, or vesication of the fingers and toes, show themselves. If it be left on beyond this, gangrene will probably set in, slow strangulation going on under the bandages without much, if any, pain. Vesications often create much alarm, but too much importance must not be attached to their mere appearance. They will often occur of very large size, as has already been stated, as a consequence of the raising of the cuticle by the transuded serum of extravasated blood. It is only when associated with coldness of the limb, a dusky purple hue, and a putrescent odour, that they are indicative of gangrene. An excellent plan of judging of the activity of the circulation in a fractured limb after it has been put up, is to leave the ends of the fingers or toes uncovered by the bandage; when, by pressing upon one of the nails, the freedom of the circulation may be ascertained by noticing the rapidity with which the blood returns under it. A question of much medico-legal importance occasionally arises in connection with gangrene of the limb after simple fracture. It is this—is the gangrene owing to over-tight, and consequently negligent, bandaging by the Surgeon, or to passive strangulation by inflammatory swelling of the limb under bandages not originally too tightly applied? The diagnosis of the two conditions on which the answer is depen-

dent is as follows. 1. When a bandage has been originally too tightly applied, the patient will suffer severely for several hours, the pain being felt immediately after the application of the apparatus. On loosening the bandage, the pain ceases. When removed, if gangrene have set in, the skin will be found pale where the roller has been applied—the limb being compressed and small at this part, and marked with imprints at the edges of the turns of the bandage—whilst it is greatly swollen and congested at the fingers or toes beyond the bandage: these parts being also cold, purple, and vesicated. 2. When the strangulation occurs from inflammatory swelling of the limb, the whole member is equally swollen; it is red and blue, hot in parts, cold and sphacelated in others. It never becomes uniformly gangrenous, but deep infiltrating abscess, and localized sphacelus, form.

Treatment.—When a bandage or apparatus appears to be exerting undue, painful, or dangerous pressure, it must at once be removed. Should the circulation of the limb have been interfered with, friction with oil in an upward direction should be employed.

If gangrene have unhappily already occurred, the treatment will depend on the cause, and the condition of the limb. If the gangrene be the result of self-strangulation of the limb, by its swelling up under the bandage, and it be found to be red, swollen, and infiltrated, free incisions should be made, and some efficient antiseptic dressing applied. If, notwithstanding this, abscesses form, with deep infiltration of the cellular tissue, and sloughing of the skin and muscles, the choice lies between amputation and the preservation of a limb that will be withered, contracted, and useless.

If the gangrene be the result of direct strangulation of an over-tight bandage, as in Fig. 181, there is no resource left but amputation above the seat of constriction.

After a fracture has united, the limb will sometimes be found to be **shortened**. This may of course be due to unskilful management on the part of the Surgeon, to want of proper coaptation of the fragments, or to the patient being allowed to bear on the limb whilst the callus is still soft and pliable. But it may have existed before the accident, be natural to the patient, and in no way a consequence of the accident.

Inequality in the length of the corresponding limbs on opposite sides of the body, independently of any accident or disease, is not very unfrequently met with. It will exist to a considerable extent without the patient being aware of it. I have several times found the spinal curvature of young adults to be due to one lower extremity being from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch shorter than the other, and thus causing obliquity of the pelvis. It is usually the right limb that is the longer, but in some cases the left is not only longer but larger. Of 512 boys examined by Morton, of Philadelphia, appreciable differences between the two limbs were found in 271 cases, from $\frac{1}{8}$ of an inch in 91, to as much as $1\frac{3}{8}$ inch in one. The bearing of these facts on the cause of shortening of limbs after the treatment of fractures, and the question of malpraxis, is evident. The shortening of a limb in a growing child after fracture may also be due to its necessary confinement in splints, and to the inaction causing interference with its growth, or to implication of an epiphyseal cartilage, and not to the fracture having been inaccurately adjusted.

Complicated Fractures.—Fractures may be **complicated** with various important local conditions. Extravasation of blood into the limb, from a

wound of some large vessel, may go on to so great an extent as to occasion strangulation of the tissues; if not checked by position and cold applications, it may give rise to gangrene, and demand amputation. In other cases, again, the soft parts in the vicinity of the fracture may be contused to such a degree that they rapidly run into slough, thus rendering it compound; or a wound may exist, not communicating with the broken bone, but requiring much modification of treatment, and special adaptation of apparatus.

One of the most serious complications of a simple fracture is undoubtedly the **Rupture of the Main Artery** of the limb opposite the seat of fracture, or a wound of it by one of the fragments of broken bone. This accident occurs chiefly in fractures of the lower part of the femur or upper part of the tibia; the popliteal in one case, and the posterior tibial in the other, being the vessel wounded. The symptoms will depend on whether the artery is completely torn across, and has become closed and ceased to bleed, or whether it is still pouring out blood subcutaneously. In the former case the condition of the artery is indicated by the loss of pulsation in the branches beyond the injured point, and by the coldness of the limb. If the extravasation have not been too great, and if the condition of the soft parts is such as to justify a hope that the collateral vessels are not greatly injured or pressed upon, an attempt should be made to save the limb, especially if it be the upper. It should be put in the best position possible, and warmly wrapped in cotton-wool. Splints and bandages of all kinds must, as far as possible, be avoided, lest the collateral circulation be interfered with. The result will often depend much upon the cause of the fracture. If the vessel have been torn by the bone in a case of fracture by indirect violence, the prospects of recovery are much better. A case of the kind occurred not long ago at University College Hospital, in which the brachial artery was completely obliterated. The limb was wrapped in cotton-wool, and the patient made an excellent recovery with a somewhat shortened arm. If the fracture is by direct violence, and the main artery is crushed against the bone, the condition is more serious, as the bruising may seriously interfere with the collateral circulation, and gangrene may follow.

If the artery be only partially ruptured, or be torn across and not closed, hæmorrhage will continue subcutaneously. The symptoms consist in the rapid formation of a uniform elastic tense swelling of the limb, with obscure pulsation or thrill, opposite the seat of injury, and cessation of pulsation in the arteries at the ankle, with coldness and numbness of the foot and lower part of the leg. If the posterior tibial be the vessel injured, the circulation in the arteries of the foot may return after a day or two, and the coldness and numbness may lessen. If it be the popliteal that is injured, no such amelioration will take place, but the diffused aneurism in the ham will increase, the circulation will become more and more impeded, and gangrene will result.

What should be the **treatment** of such a case as this? The Surgeon has three alternatives.

1. The case may be treated as one of open arterial wound, the tumour laid open, and the injured vessel ligatured at the seat of wound. The objections to this treatment are, that a large cavity is opened, which, if it suppurate, will give rise to the most serious constitutional disturbance, the fracture being rendered a compound one of the worst kind, complicated by the great extravasation of blood amongst the surrounding parts. Securing the artery is, moreover, in any circumstances extremely difficult, and even uncertain. In

the present day the dangers of suppuration and sloughing following in the cavity, may be greatly reduced, if not abolished, by the employment of some efficient mode of antiseptic treatment, and the exposure of the artery can be facilitated by the bloodless method of operating. If the means of treatment at the command of the Surgeon are such that he may hope efficiently to prevent the injurious consequences of exposing the fracture to the air, there is no reason why he should deviate from the acknowledged rule of surgery to tie the wounded vessel at the injured spot.

2. The circulation through the femoral artery may be arrested by compression or ligature of the vessel. I am not aware that compression has ever been tried in a case of diffused traumatic aneurism ; but there can be no reason why the effects of pressure upon the artery, by means of Carte's or some other appropriate compressor, should not be tried before proceeding to more severe measures. Should it not succeed, the artery may be tied in Scarpa's triangle. An operation there has several times been successfully done in such cases, more especially when the hæmorrhage has been the result of laceration of the posterior tibial artery. But this operation should be done only in those cases in which, notwithstanding the existence of diffused traumatic aneurism in the ham, the pulsation has returned in the arteries of the foot, and the warmth and sensibility of the member have been in part at least restored. If these evidences of a return of circulation through the anterior tibial have not taken place, it will be worse than useless to ligature the femoral, as gangrene must inevitably ensue.

3. Amputation of the thigh may be performed. This severe measure need not be carried out at once. The Surgeon may wait a day or two and watch the progress of events. If he find that there is no sign of restoration of pulsation in the arteries of the foot, that the coldness and numbness of the limb continue to increase, and, in fact, that gangrene is impending, then the sooner he amputates the better for the patient's safety. If the artery have been tied, and gangrene result, the limb ought at once to be removed.

To sum up, I would advise, in a case of diffused traumatic aneurism arising from and complicating a simple fracture of the lower extremity : 1. Not to lay open the tumour and search for the artery at the seat of wound, unless the local conditions are favourable, and antiseptic treatment can be efficiently carried out ; 2. To compress or tie the femoral if pulsation have returned or continue in the arteries of the foot ; 3. But should pulsation not have returned within two or three days, should gangrene be imminent, or actually have set in, or should the artery have been ligatured, and mortification have ensued, to amputate high in the thigh without further delay.

It will thus be seen that, in a diffused traumatic aneurism complicating a fracture of the bones of the lower extremity, the ordinary treatment of diffused traumatic aneurism must, except under very favourable conditions, be departed from, for these reasons. 1. That if there be great displacement of the parts, and laceration of the soft structures consequent on the fracture, it would be almost impossible to find the injured vessel ; and 2. That, if it were found, the opening up of the limb would leave a large ragged wound communicating widely with the broken bones, and, except under successful antiseptic treatment, it would in all probability give rise to wide-spreading septic inflammation, accompanied by severe fever, and followed by prolonged suppuration, which would most probably terminate fatally.

However extensively a bone may be **comminuted**, good union will take place provided the fracture be simple; that is, provided no wound exist in the limb by which air may gain admission to the fracture or to the soft parts implicated in it. I have seen the lower end of the femur crushed, as if by a sledge-hammer, into a multitude of fragments; and yet excellent union resulted, the fracture being simple, without even a breach of integument. In such a case as this, if there had been the smallest wound to admit unpurified air into the limb, decomposition of the effused blood would in all probability have followed, with the most intense and destructive septic inflammation and suppuration, and the patient's limb, if not his life, would have been lost. It is impossible to over-estimate the advantage of an injury of this kind being *subcutaneous*. The whole of the dangers that arise from the admission of unpurified air result from the decomposition that it sets up. It is the object of the antiseptic treatment of compound fracture which will be described hereafter to counteract the dangers arising from the admission of air, and thus to render a compound fracture but little more dangerous than a simple one.

A serious complication of simple fractures consists in their **Implicating a Joint.** The fracture may extend into a neighbouring articulation, and thus give rise to considerable inflammation; in strumous subjects this may lead to ultimate disorganization of the articulation, requiring excision, which I have several times had occasion to perform in these cases. But in healthy individuals a large articular surface may be traversed by lines of fracture in several directions, without material inconvenience resulting. This we see in impacted fractures of the condyles of the femur or of the lower end of the radius. In several instances of this kind in which I have examined the limb after death, no sign of disease of the part has been manifested beyond a moderate amount of injection of the ligaments; the fractured incrusting cartilage uniting by plastic matter, and the synovia being clear and free from inflammatory exudation. But, although union of fractures extending into articulations takes place readily enough, it cannot be expected that the patient will recover with as mobile a joint as if the fracture had traversed merely the shaft. In fact, in the majority of these cases, the patient will be left with a joint that is weak, stiff, and painful: and, if in the lower extremity, the limb may be unable to support the weight of the body for some considerable time. Possibly also, in many of these instances, an impaired joint will be left through life, as the necessary and unavoidable result of the injury, though not unfrequently unjustly attributed to negligence and want of skill on the part of the Surgeon. Hence it is a wise precaution for the Surgeon when called to a case of fracture involving any one of the six larger articulations, viz., the shoulder, elbow, wrist, the hip, knee, or ankle, to warn the patient that some degree of impairment of the free use of the limb will in all probability result.

The occurrence of **Dislocation** at the same time and from the same violence as the fracture often causes great difficulty to the Surgeon; as it becomes necessary to reduce the dislocated joint before the fracture is consolidated. In several instances of this description which have fallen under my care, I have succeeded in reducing the dislocation at once, by putting up the limb very tightly in wooden splints, so as to give a degree of solidity to it, and to permit the lever-like movement of the shaft of the bone to be employed; and then, putting the patient under chloroform, I have replaced the bone without much difficulty. Should the Surgeon have omitted to reduce the

dislocation in the first instance, he must wait until the fracture has become firmly united, and then, putting the limb in splints or in starch, he may try to effect reduction, which, however, will then be very difficult.

The fracture in a limb which is the seat of an **old Unreduced Dislocation** is necessarily of very rare occurrence, but occasions no serious difficulty in diagnosis or treatment. I once saw and treated successfully with Dr. Bryant a case of this kind in the person of an old gentleman who, falling on the ice, fractured the left humerus, which had been the seat of an unreduced dislocation forwards for more than fifty years.

The existence of **an Ankylosed Joint** in a fractured limb gives but little trouble, beyond the necessity of modifying the splints in such a way as to fit the shape of the limb. I have treated fractures of the thigh, leg, and arm in such circumstances with perfect success, by adapting the splints to the angle formed by the stiffened joint.

Fracture of a bone into the **Site of an Excised Joint** presents no peculiarity of importance. I have met with it in the humerus at the elbow, and have treated the case as one of ordinary fracture of the epiphysis.

Fracture of the bone in the **Stump of an Amputated Limb** is a rare accident. I have twice had such cases under my care ; once in a man, and another time in a woman, each of whom fractured the femur low down in a limb which had been amputated below the knee. There was no displacement of the fractured bone in either case, showing the influence of the weight of the limb in addition to muscular contraction in occasioning displacement of the lower fragment. In each case the accident was the consequence of a fall, and union readily took place under the starched bandage.

In cases of simple fracture occurring in the neighbourhood of, or implicating large joints, passive motion is very commonly recommended at the end of from four to six weeks ; I think, however, with Vincent, that this is often apt to do more harm than good, and is seldom required, the natural action of the muscles of the part being fully sufficient to restore the movements of the articulation, with the assistance of friction and douches.

Amputation is but very seldom required in simple fractures, and I have never had occasion to practise it. Yet, in cases of very extensive and severe comminuted simple fracture of the lower end of the femur, or of the upper part of the bones of the leg, with implication of the knee-joint and injury to the popliteal or tibial arteries, as indicated by the cessation of pulsation in the vessels of the foot, removal of the limb might be proper, in order to save the patient from gangrene or diffused traumatic aneurism. But it is only when the main artery has been injured by spicula of fractured bone, that such fractures will require amputation. I have had under my care a man, in whom the condyles of both femora and the left patella were crushed into numerous pieces by a fall from a great height on the knees, the limbs at the seat of the injury feeling like bags of loose fragments of bone ; yet, as neither the skin was broken nor the main vessels injured, though both knee-joints appeared to be disorganized, the limbs were preserved, and good union ensued.

Compound Fracture.—A compound fracture is that form of injury in which there is an open wound leading down to the broken bone at the seat of fracture. Thus the term includes injuries varying in severity from a simple fracture complicated by a small punctured wound of the skin made by one of

the fragments to a complete smash of the whole limb, such as is made by a railway-train passing over it. Compound fractures therefore include many injuries far more severe than any simple fracture can possibly be; but, in a very large proportion of cases, the injury to the soft parts and the splintering of the bone are no greater than in many simple fractures, the sole difference being that, in the one case, there is a wound by which air, carrying with it the causes of decomposition, can find access to the decomposable blood-clots and inflammatory exudation surrounding the broken ends of the bone, while in the other it is excluded by the unbroken skin. As a consequence of this, unless special means are taken to prevent it, decomposition sets in, the blood-clot breaks down and is discharged, and the septic matter in the cavity of the wound excites inflammation, reaching the stage of suppuration, in the surrounding tissues. Portions of the bruised muscles and the torn periosteum, which in a simple fracture would either have recovered, or if too severely injured would have been penetrated by wandering leucocytes and absorbed, may perish in consequence of the additional irritation caused by the septic matter and finally be cast off as sloughs. From the same cause portions of the ends of the bones which may have become denuded of their periosteum, or detached splinters, perish and come away as sequestra. In many cases also the external wound is too small to allow of efficient drainage and consequently the pent-up septic matter burrows widely in the intermuscular spaces of the limb. If, therefore, the decomposition of the discharges cannot in some way be prevented, a compound fracture is not only far more tedious in its cure than a simple fracture, but infinitely more dangerous. It has to unite by a slow process of granulation instead of the more speedy mode of union already described as occurring in simple fractures. The dangers of a compound fracture arise also from the decomposition of the discharges consequent upon the admission of unpurified air. During the first week there may be severe septic fever; and the stages of granulation and suppuration are often attended by profuse discharge of pus from the original wound and from abscesses forming amongst the surrounding muscles, maintained for a long time by exfoliation from the ends of the fractured bone. The patient may thus be worn out by the prolonged suppuration and the persistent absorption of the products of putrefaction; or the wound may become the seat of some infective process, and he may perish from septicæmia, pyæmia or erysipelas. In other cases the septic inflammation may spread to the medulla of the bone, causing diffuse osteomyelitis, followed by extensive necrosis, a condition frequently terminating in pyæmia. Thus a compound fracture leads not unfrequently to the eventual loss of life or limb. Besides these dangers, which may be looked upon as indirect, the violence that occasions a compound fracture often shatters the limb to such an extent, as to lead to the immediate supervention of traumatic gangrene, to the loss of life by hæmorrhage, or to the certain and speedy disorganization of the limb, as the consequence of the subsequent inflammation.

Union of Compound Fractures.—If the superficial wound heal by the first intention or if the evil effects of the admission of unpurified air and the consequent decomposition of the discharges can be prevented, a compound fracture may unite in exactly the same way as a simple fracture. Under other circumstances union takes place more slowly by granulation, just as in wounds of the soft parts healing by the second intention. If the injury of

the soft parts be but slight and the drainage good, the first process is an abundant inflammatory exudation from the vessels of the injured tissues. This coagulates, the serum draining away partly by the open wound and partly by the lymphatics, and the fibrine, entangling the white corpuscles in the meshes of its coagulum, forms a layer of "coagulable lymph," or plastic exudation, which covers the injured soft parts and closes the intermuscular spaces. The exudation is very abundant round the bone, and the swollen and infiltrated periosteum, fused with the neighbouring tissues, soon forms a soft mass surrounding the broken ends, as in a simple fracture. Similar changes occur in the medulla. Then follows the formation of new vessels and the development of granulation-tissue; the wound slowly closes up from the bottom, the broken ends becoming gradually completely imbedded in the growing granulation-tissue. Finally, ossification takes place. This commences in contact with the bone on each side in the granulation-tissue at the point furthest from the seat of fracture. It occurs without the previous formation of cartilage, even in the lower animals, or at any rate with the development of merely a few irregular islets. The intercellular substance increases in quantity, the cells assume the angular form of osteoblasts, and then follows the deposit of lime-salts and the development of true bone. The new bone gradually encroaches on the granulation-tissue, and the fractured ends are surrounded by it. The remaining changes are the same as those in a simple fracture. In cases in which the injury has been more severe and in which the process is complicated by the presence of portions of muscle which have been either directly killed by the violence which caused the fracture, or have perished from the combined effects of the injury and of the irritation of decomposing discharges, or by loose splinters, the process of union cannot take place till these are slowly separated by ulceration from the surrounding living parts and are thrown off. In other cases in which the denuded ends of the bones perish, the process of separation may not be complete for many months after the injury. Under these circumstances the sequestra may be surrounded by a mass of new bone uniting the upper and lower fragments and perforated by openings for the discharge of pus from the granulations lining the cavity in which the dead bone lies, and thus a tolerably firm union may take place long before the wound has healed. This process necessarily, in the great majority of cases, occupies a much longer time than that which is required for the union of a simple fracture. A considerable proportion of all compound fractures, however, undoubtedly unite without the occurrence of necrosis.

Question of Amputation.—As compound fracture is attended not only by prospective dangers, but also by serious immediate risk, the first question that always presents itself in a case of this injury is, whether the limb should be removed, or an attempt be made to save it. It is of great importance to settle this point at once; for, if amputation be determined upon, it should be done with as little delay as possible, there being no period in the progress of the case so favourable for operation as the first four-and-twenty hours. Should an injudicious attempt have been made at saving the limb, the Surgeon must wait until suppuration has been set up and the septic fever is beginning to subside before he can remove it; and then, he will very commonly find that the occurrence of some of the diffuse inflammatory affections will render any operation impracticable: or the supervention of traumatic gangrene may compel him to amputate in the most unfavourable circumstances. At a late

period in the progress of the case, amputation may be required, in order to rid the patient of a suppurating limb that is exhausting him by profuse discharge.

It is true that primary amputations are very commonly fatal, especially when practised near the trunk; yet this cannot with justice be urged as an argument against their performance, as recourse should never be had to *primary* amputation except in cases in which it is evident that the patient's life must in all probability be sacrificed by an unsuccessful attempt to save the limb. In determining the cases in which immediate amputation should be performed, no very definite rules can be laid down, and much must at last be left to the individual judgment and experience of the Surgeon. One will attempt to save a limb which another condemns. But, in coming to a conclusion upon this important question, he must bear in mind that, though it is imperative to do everything in his power to save a limb, yet the preservation of a patient's life is the main point, and that course is the proper one which offers the greatest prospect of effecting this. A wise conservatism is much to be applauded, but decision in determining the expediency of amputation is equally characteristic of a good Surgeon. In deciding on a question of such vital moment as this, he must consider not only the nature and extent of the fracture, but the age, constitution, and habits of the patient: and though he may be guided by those general rules which have already been laid down at pp. 320 and 341, when treating of amputation in contused wounds and in gun-shot injuries, yet he will often show more wisdom and a greater amount of skill, in departing from the strict letter of surgical law, and in making a successful effort to save a limb, which, by adherence to surgical precepts, would be condemned; or in attempting to preserve the patient's life, by sacrificing a limb that is not injured to a degree that would usually be considered to justify amputation.

1. Those fractures must be looked upon as most unfavourable in which the wound is the consequence of the violence that breaks the bone, and, in which there is **much Laceration of, and Extravasation into, the Soft Parts**; more particularly if the integuments be stripped off, portions of the muscular bellies protrude, and the planes of areolar tissue between the great muscles of the limb be torn up and infiltrated with blood. Injuries of this description occurring in the lower extremity always require amputation. The danger to the patient increases not only in proportion to the amount of comminution of the bones and of injury to the soft parts, but almost in the exact ratio of the proximity of the injury to the trunk. Thus, amputation of the thigh for bad compound fracture of the leg, though a very serious operation, is sufficiently successful; but when the femur itself is badly fractured and amputation of the thigh high up is required, recovery can indeed but seldom be expected. A bad compound fracture of the thigh, high up, may be looked upon as almost a fatal accident (*vide* pp. 105 and 344). In the arm, such accidents are not so serious, and the member may be saved, unless the bones be greatly comminuted.

2. The complication of a compound fracture with the **Wound of a Large Joint**, more especially if there be crushing or splintering of the bones which enter into its formation, with extensive laceration of the soft parts, is one of the most serious injuries that can be inflicted on a limb; and, when occurring in the lower extremity of an adult, is a case for amputation—unless it be the hip-joint that is damaged, when there will generally be so much injury of the

pelvic bones and their contained viscera, as to preclude the performance of any operation. In children recovery may be effected in cases that would be hopeless in the adult; and under antiseptics many limbs, in which the joints are opened by fracture of contiguous bones, are saved that were formerly doomed to the knife. When the elbow- or the shoulder-joint is the seat of compound comminuted fracture, with extensive injury of the soft parts, and possibly laceration of contiguous nerves or large blood-vessels, the case is one for immediate amputation. But, if the injury be limited to the bones, the soft parts being in a favourable state, resection of the articulation may advantageously be practised. This operation is usually a somewhat irregular proceeding, being conducted according to the extent of the wound, and consisting rather in picking out the shattered fragments of bones, and sawing off projecting and sharp-pointed fragments, than in methodical excision.

A peculiar accident is occasionally met with in young people, consisting in a **fracture** of one of the long bones **at the junction of the shaft and epiphysis**, and the protrusion of the end of the shaft through the muscles and integuments. In these cases, although the fracture is in close vicinity to the joint, the articulation is not affected, and careful examination will always prove its sound condition. Reduction in such cases is difficult, and it is usually impossible to maintain it without sawing off the projecting end of the shaft. This is easily done, and union takes place readily between the epiphysis and the remainder of the shaft. In two instances in which I have had to do this in lads, one near the shoulder, the other near the ankle, an excellent result without impairment of freedom of action in the joint followed the operation.

3. When one of the **larger Arteries of the Limb has been wounded** by the violence that occasions the fracture, or has been lacerated by the broken bone itself, there may be copious arterial hæmorrhage externally, as well as extravasation into the general areolar tissue of the limb. These cases most commonly require immediate amputation. Whilst the patient is being examined, and preparation made for the operation, dangerous effusion of blood must be prevented by the application of a tourniquet. For want of this simple precaution, I have seen very large and even fatal quantities of blood gradually lost, by being allowed slowly to trickle from the wound.

In these cases it has been proposed, by some Surgeons of great eminence, to enlarge the wound in the limb, or to make an incision down to the fracture, and attempt to tie the artery where it has been injured. It is easy to give, but difficult to carry out, such precepts. In most cases they are scarcely practicable, as the Surgeon would have to grope in the midst of bleeding and infiltrated tissues, and would experience the greatest possible difficulty in finding the wounded vessel, after a search which would materially tend to increase the disorganization of the limb. Even after the amputation of a limb in this condition, it is often by no means easy on dissection to find the artery that has poured out blood; and how much more difficult must it be to search for it successfully during life!

The ligature of the artery at a higher point of the limb does not hold out much prospect of success, for the same reasons that render its performance inadmissible in ordinary wounds of arteries (p. 431). This operation has succeeded in restraining hæmorrhage or in curing diffused traumatic aneurism in simple fractures. But I know of no case in which it has been successful in

the permanent arrest of *primary* hæmorrhage in a compound fracture. If, then, proper means directed to the wound, such as position, pressure, or perhaps the attempt at ligature if the artery can be easily reached, be not successful, no course is left to the Surgeon but to amputate the limb without delay. This is more especially the case if it be the lower extremity that is injured : in the arm, there is a better prospect of our being able to arrest the bleeding without having recourse to this extreme measure. *Secondary* hæmorrhage occurring in the course of treatment of a compound fracture of the lower extremity is far less serious than primary. It has been arrested by pressure and bandaging, and in many cases by ligature of the superficial femoral. Amputation, therefore, may be delayed in these cases until after the consecutive employment and failure of these two methods.

4. **Comminution or Splintering of the Broken Bone** is always a serious complication of a compound fracture. Here the case is very different from what occurs in similar circumstances in a simple fracture. Extensive suppuration will set in : the splinters, if completely or nearly detached, will lose their vitality, and not only produce all the irritation that would result from the inclusion of rough and pointed foreign bodies in the interior of a limb, but, if numerous, will, on their removal or separation, leave the member shortened and permanently deformed. The treatment of such cases will depend on the seat of the injury, and the extent of the comminution. Compound and comminuted fractures of the femur, may, except when occurring in the upper third, generally be looked upon as cases for immediate amputation (*vide* p. 344) ; the only other exceptions being when the comminution is trifling, the splinters large, and lying in the axis of the bone, and the subject young. In the arm, fore-arm, and hand, and in the leg, provided the knee and ankle-joints be not involved, much may be done in the way of removing splinters of detached bone, and sawing off smoothly the rugged ends of the fixed fragments. The larger attached and "secondary" pieces should be left, as they will throw out callus, and become buttresses of support to the broken bone (*vide* p. 510). If a considerable quantity of splintered bone have been extracted from a limb, care must be taken that in putting up the fracture too complete extension is not maintained, lest a gap be left, which cannot be filled up by new bone, and a weakened limb result. It is better to place the bones in proper apposition, and to let the patient recover with a shortened but strong and otherwise useful limb.

5. The complication of a **bad Compound Fracture requiring Amputation low down in a Limb, with a simple Fracture high up**, is a serious one. The question that will here arise is : Should the amputation be performed above the compound and below the simple fracture, or above both ? The answer to this must depend on the condition of the limb between the fractures. Suppose that there be a badly comminuted and compound fracture of the lower third of the leg, with a simple fracture of the middle of the thigh ; or a crush of the hand or fore-arm, with simple fracture of the middle of the humerus : how should the Surgeon act ? It appears to me that the proper course to adopt in such a case as this, would mainly depend on the conditions of the intermediate soft parts. If these be sound, free from extravasation, not contused or lacerated, the limb may with safety be removed just above the lower fracture, the upper fracture being treated on ordinary principles. But if there be extensive bruising of the limb with ecchymosis or deep extravasation between the fractures, then it would clearly be useless to amputate low down, as not only

would the stump have to be formed of severely injured tissues, but if septic inflammation set in at the seat of operation, it would speedily spread upwards to the higher fracture, converting it into a compound one of the worse kind. In such cases, therefore, where there is extensive disorganization of the intervening soft parts, it appears to me that the proper course for the Surgeon to pursue is to remove the limb at or above the line of the higher fracture.

6. The complication of a **Dislocation high up with a bad Compound Fracture low down**, as when the shoulder is dislocated, and the hand is crushed, is not so serious ; the dislocation having been reduced, the limb may be amputated low down with safety. This practice I had occasion to adopt some years since in a young man who met with a bad crush of the hand and fore-arm, with dislocation of the humerus into the axilla, in consequence of the limb having become entangled in machinery. If, however, the compound fracture, unattended by any of the complications that have just been mentioned, occur in a young or otherwise healthy subject, we must, of course, attempt to save the limb, and shall generally succeed in doing so.

In some cases in which there is great doubt as to the possibility of saving the limb, especially in compound fractures of the upper limb and foot, the injured part may be dressed antiseptically, and amputation, if necessary, performed at a later period. The entire exclusion of putrefaction will prevent the septic fever, the spreading inflammation, and the dangers of general infection, which in former times made it safer to perform a primary amputation in all cases in which the prospects of recovery without were very doubtful.

Treatment of Compound Fracture.—In the management of a compound fracture, more especially of the lower extremity, special apparatus, such as M'Intyre's, Liston's, or the bracket-splints, double inclined planes, swing-boxes, and fracture-beds, are often necessary, in order to obtain access to the wound, so as to dress it properly, and to place the limb in the best position for union. In many cases the starched or plaster-bandage may very advantageously be used ; but it requires caution, as swelling and consequent strangulation of the limb may take place under it.

There are several points that require special attention. These are : 1, the Reduction and the Management of any Protruding Bone ; 2, the Management of Splinters ; 3, the Treatment of Oozing of Blood ; 4, the Treatment of the Wound. Together these make up the whole treatment of these injuries, in cases in which the limb admits of being saved.

1. The **Reduction of compound fractures** must be accomplished with the same care and gentleness as that of simple ones. In the majority of cases, no great difficulty is experienced ; and after reduction, the limb should be placed on a well-padded splint, properly protected in the neighbourhood of the wound with oiled silk, so as to prevent soiling of the pads by blood and discharge. In some cases, however, considerable difficulty arises in the reduction, from the protrusion of one of the broken fragments which has been driven through the skin, at the time of the accident, or by careless handling of the limb in carrying the patient, or else by the muscular contractions dragging the lower fragment forcibly upwards, and thus causing perforation of the integument. The protruded bone, after being carefully cleaned with some antiseptic solution, must, if possible, be gently replaced, by relaxing the muscles of the limb, and then bringing the soft parts over it. Sometimes, however, it is so tightly embraced by the skin, which appears to be

doubled in underneath, that enlargement of the wound becomes necessary before it can be replaced. In other cases, again, reduction cannot be effected or maintained, unless the sharp and projecting point of bone be sawn off. This is best done with an ordinary amputating saw, the neighbouring soft parts being protected with a split card; or else by passing the blade of a Butcher's saw under the bone and cutting upwards. The limb, as I have found in several cases in which it has been necessary to have recourse to this procedure, is not ultimately weakened nor, necessarily, shortened by it.

2. In the **Management of Splinters** the Surgeon will be guided by the circumstances. If the splinter be completely loose and small it is always better removed. If it be very large, two inches or more in length, forming in fact rather a fragment of the bone than a splinter, it may be left, even when completely loose. If a splinter is still attached by periosteum it may usually be safely left, even when small.

3. **Treatment of Oozing of Blood.**—In cases in which there is evidently no important vessel wounded, blood often continues to ooze slowly from the wound, and it becomes a question whether anything should be done to arrest it. The only means at our command are elevation of the limb, cold, and pressure. The two former of these may be resorted to whenever the oozing may seem sufficient to render it necessary, but pressure should be avoided if possible. The blood is coming in all probability from the deep parts, very often from the bone itself; pressure, therefore, cannot be applied to the bleeding surface. If applied externally it merely causes the intermuscular spaces and the cavity of the wound to be distended with blood, and should decomposition follow the consequences are most serious. The oozing will always stop by itself after a few hours, and if the patient should lose a few ounces of blood in that way it is better than having the same quantity extravasated into the limb.

4. The **Treatment of the Wound.**—After the reduction, the great object is, if possible, to convert the compound into a simple fracture by the **closure of the external wound.** If this can be accomplished, the danger and delays of suppuration are avoided. The chance of successfully closing the wound in the soft parts will depend upon the size of the wound and whether it has been made by transfixion of the skin by the sharp angular fragment, or by the direct violence which has occasioned the fracture. If the wound be small, clean cut, and occasioned by the protrusion of the fragment rather than by the direct violence which occasioned the fracture, we may hope to succeed in our object by following Sir A. Cooper's recommendation of applying to it a piece of lint soaked in blood, or, what is better, saturated with collodion or with tincture of benzoin, and thus obtaining union under a scab. The dressing should be left undisturbed until it loosens of itself, at the end of a week or two, when the wound will probably be found to be closed. If, however, the patient after a few days begin to complain of pain, if the temperature rise and the leg become red, hot and swollen, the crust must be at once removed; and if pus flow from beneath it, it is safer at once to enlarge the wound freely.

Supposing the case to be one in which from the size of the wound, or the amount of swelling, it is evidently impossible to hope to close the wound by scabbing, the Surgeon must then be guided by the same principles as in the treatment of any other open wound. The objects in view are, 1. To

clean the wound thoroughly; 2. To provide good drainage; 3. To prevent decomposition of the discharges and infection of the wound; and 4. To maintain perfect rest.

Cleaning the Wound.—It is better in all cases, whatever mode of dressing it is intended to adopt, to syringe the wound out with some antiseptic solution, as by this means any dirt which may have been forced into the wound at the time of the accident, or have adhered to the bone if it have been protruded, may be washed out. The best solutions are carbolic acid and water (1 to 20); tincture of iodine and water (1 to 80): or chloride of zinc (20grs. to an ounce). The skin round the wound may also be cleaned with the same solution. It is better, however, not to wash it at all, but to wipe the surface clean with dry rag or cotton-wool, rather than to use common unpurified water. In syringing out the wound, a glass syringe with a piece of stiff india-rubber tubing on the nozzle should be used. This will penetrate all parts of the wound and yet is not rigid enough to force its way amongst sound tissues. The lotion must be allowed to flow out freely, so as to avoid injecting the surrounding lymph-spaces. Having cleaned the wound thoroughly, *provision must be made for efficient drainage.* In many cases the wound is large enough to allow of perfect drainage; if it should not be so, it may be enlarged, but it is scarcely ever justifiable, however large the wound may be, to insert stitches. If the skin is much undermined a counter-opening may often be made with advantage, and a drainage-tube inserted. The *prevention of decomposition of the discharges and infection of the wound* is carried out by one of the methods of dressing already described in the Chapter on Wounds. Amongst these the carbolic-gauze-dressing will be found one of the most certain and most successful, and a few points require notice with regard to its application to compound fractures. In many compound fractures the air gets sucked in by the movements of the limb, and can be felt crepitating in the subcutaneous tissue for some distance on each side of the wound. In these cases it is not necessary to force the solution as far as the air has gone, as it seems to deposit its dust close to the wound, where it can be reached easily by the disinfectant. If the wound is many hours old or very dirty, it is well to put into it some iodoform in crystal to ensure a more permanent disinfecting action. In applying the dressing care must be taken in wrapping it round the limb to see that it is so arranged that it can be opened when it requires changing, while the limb is lying well supported and in a comfortable position. Thus in the case of a fracture of the leg treated by Cline's lateral splints, the edge of the dressing should be under the internal splint so that it can be opened without disturbing the fracture while the leg lies on the outer splint. The dressings must be held in position by the splints; no bandage must be put on under the splints, as it is impossible to do this without disturbing the ends of the bone. The dressing must, in ordinary cases, be changed at the end of the first twenty-four hours. It will be found to be soaked in an abundant red serous discharge; the wound will be completely filled by a smooth layer of blood-clot, level with the skin, which must on no account be disturbed. It must be covered immediately with a fresh piece of "protective," and a double layer of wet gauze and the dressing reapplied. After this it is not necessary to dress the wound till the discharge shows at the edge of the dressing. If all goes well the blood-clot remains unchanged, or at most becomes grey on the surface until, after a variable period, from

two to three weeks, it will be found to have been completely replaced by granulation-tissue, which has gradually grown up from beneath and absorbed it. There is no reason to believe that the clot itself becomes organized. If the wound be very small and the fracture unaccompanied by much injury to the soft parts, it frequently happens that the dressing can be left unchanged for two weeks or more, when the wound will be found to have healed as if under a scab. In carrying out the antiseptic treatment by the carbolic-gauze-dressing, the spray will be found to give additional security, but it is the least essential part of the treatment. Unskilful dressing will, however, undo half the good done by the prevention of decomposition ; the superficial clot is broken down, the growing granulation-tissue torn, and suppuration frequently follows from rough handling during the time the dressing is being changed. The results of this treatment of compound fractures have been very satisfactory.

The dry antiseptic dressings, as iodoform-wool, salicylic wool, and salicylic silk, have also given excellent results ; as also has the terebene-and-oil-dressing. These, as they do not require changing so frequently, give more perfect rest than the antiseptic gauze-dressing ; but they are not as certain in the prevention of decomposition.

If, as must frequently happen, the necessary materials are not at hand for a genuine antiseptic dressing, the wound must be treated by strict attention to cleanliness, rest, and drainage. Antiseptic lotions may be used, and the wound be left as open as possible for the exit of discharges. If these be retained in the limb by the external wound being kept closed by the dressing, deep infiltration of the areolar inter-muscular planes will ensue, with much tension and diffuse suppuration accompanied by severe constitutional disturbance, and followed probably by pyæmia. It is, I believe, in consequence of the free vent thus afforded to the discharges, and of their retention being avoided, that many of the worst-looking cases of compound fracture, especially of the leg—those in which there has been extensive sloughing of the soft parts around the wound, with exposure of the fractured fragments—eventually do the best. The danger in such cases is a remote one, from hectic and exhaustion ; not an immediate and grave one, from septic absorption, resulting from the infiltration of the limb.

If the antiseptic treatment fail or cannot be made use of, and suppuration takes place, with decomposition of the discharges, an endeavour must be made to *moderate the inflammation* and lessen the *constitutional disturbance.* This is best effected by fixing the limb on a splint in such a way that, although the wound can be cleaned and attended to, the apparatus shall be left undisturbed and untouched as long as possible. The great art in the successful treatment of a compound fracture under these circumstances consists in not disturbing the limb ; for days or even weeks it may sometimes advantageously be left without interference when once it has been carefully put up. Should much swelling take place, and the wound become inflamed and sloughy, and should much inflammation be set up in the limb, this may be moderated by the application of warm antiseptic applications, the best when available being boracic acid lint moistened in warm water. The part should be elevated and but lightly covered, the bed-clothes being well raised by means of a cradle, so as not to press on the limb ; care being taken, at the same time, that the bandages be applied very loosely, merely with a sufficient degree of force to retain the limb upon the splint, as inflammatory infiltration, that might rapidly induce

strangulation of the part, is apt to ensue. The constitutional irritation must be subdued by the administration of opiates, together with an aperient; and these medicines must be repeated from time to time during the first few days. Moderate and cooling regimen must be employed, and the patient be disturbed as little as possible. In many cases, if the patient be addicted to drinking, the constitutional disturbance soon assumes the irritative form: in these circumstances, it is of great moment that support, and even stimulants, be freely given; they must be allowed from the very first, and increased in proportion to the depression of the patient's strength, or as symptoms of nervous irritation come on.

If there be much extravasation of blood into the soft parts, and bruising, great tension of the limb, followed by unhealthy suppuration and sloughing, will take place in the neighbourhood of the wound; free incisions are then required to remove the tension and strangulation of the tissues, and, by letting out the decomposing blood and pus, to lessen the risk of the occurrence of gangrene, and diminish the fever resulting from the absorption of the products of putrefaction. It is in these cases that much injury results from blindly following as a routine-practice in all cases indiscriminately, the treatment which is undoubtedly of the highest value in some; viz., that of keeping over the wound, with a view to closure by the first intention, any impervious dressing, whether antiseptic, plasters, or a pad of lint soaked in blood, that has become hard and impermeable. The natural vent to the discharge through the external opening being interfered with, deep infiltration takes place through the areolar planes of the limb, and the most extensive local mischief may result, pyæmia being almost certain to ensue. As soon as suppuration is fairly established, fomentations of boracic lint or thick moist oakum-dressing should be applied, and the wound may be sprinkled with iodoform; the burrowing of matter must be prevented by making counter-openings where necessary, and by attention to the position of the limb. The wound must be frequently syringed with carbolic-acid-lotion, Condy's fluid, or some other antiseptic. The fracture-apparatus must be kept scrupulously clean, especially in summer; the bandages changed as often as soiled, and the pads well protected with oiled silk. During this period various complications, such as septicæmia, pyæmia, erysipelas, inflammation of the lymphatics and veins, and septic pneumonia, are apt to occur, requiring special consideration and treatment; so also, if the discharge be abundant, hectic, with its sweats, and gastro-intestinal irritation may come on, requiring full support of the powers of the system, and the administration of the mineral acids and other remedies, according to circumstances. As the confinement to bed is necessarily very prolonged in these cases, often extending through many weeks and months, the state of the patient's back should be attended to, and he should early be placed upon a water-cushion, or hydrostatic bed, lest sores supervene. As the wound gradually heals, it may be dressed with some stimulating lotion as the red or blue wash. The bone will often be observed lying white and bare, bathed in pus, at the bottom of the wound. But even in this apparently unfavourable condition it may recover, granulations gradually springing up on its surface and covering it in; in other cases, necrosis to a greater or less extent takes place, and perfect consolidation does not occur until the bone has separated. Curling has shown that those portions of necrosed bone which are connected with the lower fragment are slowest in detaching themselves. In some instances a

large quantity of provisional callus is thrown out, in which the necrosed bone is implicated; and then the process of separation becomes extremely tedious and protracted, and amputation may not uncommonly become necessary, from the powers of the patient being unable to bear up in so prolonged a struggle. So soon as some consolidation has taken place, the limb should be firmly put up in gutta-percha or leather splints, with a starched or plaster-bandage, so as to enable the patient to be taken out of bed, to change the air of his room, and thus to keep up his general health. In fitting these splints, care must be taken to make an aperture opposite the wound, through which it may be dressed (Fig. 178).

Neudörfer has introduced a *dry* plaster-of-Paris dressing for compound fractures, especially those produced by gun-shot, and indeed, for all attended by excessive suppuration. From this means he derived the best possible results in the German wars of 1864 and 1866. His method is as follows. Beneath the seat of injury he places eight layers of linen cloth, and on this several pounds of dry gypsum are poured, so that it lies under and around the fracture until there is a wall heaped up on each side of the wound, which is also covered in. The linen cloths are then brought over like a many-tailed bandage, and the whole is tied up by short lengths of bandage. As the plaster becomes impregnated with pus, it is scraped off, but the wound is on no account to be meddled with ; new plaster is applied where the old, which has become pasty, has been removed. Neudörfer states that, when compound fracture has been treated by the fixed plaster-bandage, this should be generally removed at the end of fourteen days ; after this the dry method, as above described, may be applied, and no splint or other extending or containing apparatus is required. It may be observed that, as plaster of Paris does not "set" with albuminous fluids, it is not hardened by the pus, but merely absorbs it, becoming pasty.

The time required for the proper consolidation of a compound fracture varies greatly, according to the amount of injury done to the bones and soft parts, and the age and constitution of the patient. In the most favourable circumstances, it requires double or treble the time that is necessary for the union of a simple fracture. Much stiffness of the limb from rigidity of the muscles and tendons will continue for a considerable length of time ; this may gradually be removed by frictions and douches.

Secondary Amputation may become necessary from the occurrence of traumatic gangrene, and then it must be done in accordance with the principles already laid down when speaking of that operation ; but more frequently it is required from failure of the powers of the patient in consequence of septic fever, induced by absorption of the products of putrefaction from the wound and the infiltrated parts around, or by hectic resulting from chronic septic suppuration and slow necrosis of the bones. In these circumstances, by removing the source of the mischief in time and seizing an interval when the fever is at its lowest point, the patient's life will in all probability be preserved; the results of secondary amputation for compound fracture in these conditions being by no means unfavourable. Indeed it is remarkable to see how speedily the constitutional symptoms subside after the removal of the source from which the absorption of septic matter is taking place ; the patient often sleeping well and taking his food with appetite the day after the operation.

The proper period to seize for the performance of secondary amputation in

the earlier stages of the injury is often a most critical point. As a rule it may be stated that, if the limb be not removed during the first twenty-four hours, eight or ten days must be allowed to elapse before the operation is done; as during that time the patient is suffering acutely from the early septic fever, and operations during this stage are notoriously fatal. But when granulations begin to spring up in the wound and oppose a barrier to the further absorption of septic matter, the fever subsides, and the limb may be removed with the best prospect of success. The thermometer is the great guide; as soon as it has decidedly fallen from the high septic fever point of about 104° F. to 105° F. to about 100° F. or lower, the operation may be safely undertaken. Should it appear, however, that the patient is becoming rapidly exhausted, and will hardly survive to the desired time, amputation may be performed as a last chance during the period of septic fever. In these circumstances, however, the operation is seldom successful; the stump becomes sloughy, diffuse inflammation comes on, septicæmia or pyæmia may set in, and the patient speedily dies. In other cases, after the first fall of the temperature, it may frequently rise again from the formation of abscesses in the neighbourhood of the necrosed bone, or from burrowing of pus amongst the muscles; or the patient may gradually be worn out by the profuse discharge. In these cases the patient's power must not be allowed to sink to the last ebb before amputation is performed; as then the shock may destroy life, or, if he survive, the immediate effect of the operation in his weakened state predisposes him to be attacked by the various infective processes to which wounds are liable. Much as "conservative" surgery is to be be admired and cultivated, and hasty or unnecessary operation to be deprecated, I cannot but think that the life of the patient is occasionally jeopardized, and even lost, by disinclination on the part of the Surgeon to operate sufficiently early in cases of compound fracture, and by too prolonged attempts at saving the injured limb.

The success of the operation will in a great measure depend upon the *after-treatment*. Large quantities of stimulants and support are often required in London practice to prevent the patient from sinking. I have frequently given with the best results, eight or ten ounces of brandy, twelve or sixteen of port wine, or two or three pints of porter, in the twenty-four hours after these operations, with beef-tea, arrow-root, or meat, if the patient would take it, and have found it absolutely necessary to do so to obviate death from exhaustion.

At a later period, when, some weeks or months having elapsed, the fracture has not united, the bones are necrosing, and the patient is being worn out by hectic, amputation must be performed at any convenient moment, and is often done with great success if it be not deferred till too late; for here the cause of the mischief is entirely local, and the constitution, suffering only by the debility resulting from it, quickly rallies when it is removed.

Bending, Rebreaking, and Resetting Bones.—It may happen, that at the end of two or three weeks a fractured bone is found in a faulty position. At this period the bond of union is soft and yielding, and the displacement, if angular, may usually be remedied by frequent re-adjustment of the apparatus, and more particularly by bandaging the fractured fragments in opposite directions, or by the use of pads pressing on the extremities of the broken bones. If this period be allowed to pass by, and the fracture be allowed to become consolidated, it may be found to be so *badly set* that it is necessary to forcibly bend or break the callus, in order to improve the condition of the limb. When

the displacement is angular, and the consolidation not very firm, as is usually the case, this may be done readily enough ; but if the displacement be longitudinal, and much time have elapsed since the occurrence of the injury, it will be difficult, if not impossible, to remove the deformity. The bending or breaking of the callus is best done under the influence of chloroform : the fracture being then put up again, speedy and perfect consolidation will ensue. In this way I have several times remedied a faulty position in fractured bones, although from six to ten weeks had elapsed from the occurrence of the injury.

In the majority of cases, the simple force exerted by the unaided strength of the Surgeon will suffice to break the bone. But should several months have

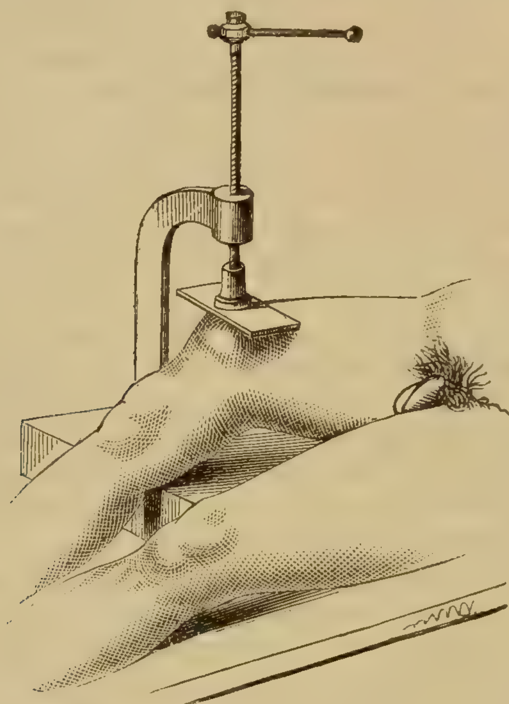


Fig. 182.—Butcher's Clamp for Re-fracturing a Badly Set Bone.

elapsed since the consolidation, the unaided strength will not prove sufficient. In such cases, Butcher has successfully employed a surgical clamp (Fig. 182), by the pressure of which the bone may be broken across at its displaced angle, even though the faulty union is of several months' duration.

Should the consolidation of the fracture be too firm to admit of re-bending, or re-breaking, *subcutaneous osteotomy* may be employed in some cases with advantage. This may be done by means of a chisel, or by Adams's narrow-bladed saw. With this latter instrument I have divided the fibula in a badly-set Pott's fracture, where the bone had united at an angle pointing inwards, and thus throwing the outer edge of the foot upwards. The same operation may be applied to other bones, especially to those of the fore-arm.

A bone which does not appear to have been very skilfully set, and which presents a certain amount of deformity when the splints or apparatus covering it are removed, may gradually regain its proper shape if left to itself. This it does by the muscles of the limb moulding the callus, whilst still somewhat soft

and yielding, into a proper shape. The callus may be quite strong enough to bear the weight and to maintain the length of the limb in its full integrity after the removal of all apparatus, and yet be sufficiently yielding to become slowly and gradually shaped by the action of the muscles of the limb when they are left untrammelled by bandages.

But it more commonly happens that a limb which, when taken out of the splints at the proper period, appears to be straight and of good length, gradually yields under the weight of the body and the strain of the muscles : so that, at the end of a few weeks, great and most unsightly deformity occurs. In these cases the Surgeon is often unduly blamed ; and to his unskilfulness is attributed that displacement which, in reality, is due to the faulty character of the callus. It must be remembered that there is every degree of firmness of the callus, from that which is of normal consistence to that which is quite unable to support the weight of the limb or body, and that yields more or less quickly under the pressure to which it is subjected.

Delayed Union.—Occasionally, more particularly in cases of fracture of the femur, tibia, and humerus, the union between the broken fragments is *delayed* several weeks beyond the usual period of perfect consolidation. This arises, in the majority of cases, from constitutional debility, rather than from local causes. Several cases of delayed union have been recorded in which repair readily took place after the employment of mercury; indeed, in syphilitic subjects the constitutional taint should always be treated. A not unfrequent cause of delayed union is "meddling" with the fracture, changing the apparatus, removing splints or frequently testing the solidity. When it is found at the expiration of six or eight weeks after the occurrence of simple fracture that the callus is still yielding, the general health should be improved by tonics, change of air, &c., and the limb securely put up in starched or plaster-of-Paris bandages. Indeed, I believe that delayed union is much less likely to occur in patients who have from the first been treated by the starched bandage, and allowed to move about, than in those who have been confined to bed or rather to the house in the ordinary way.

Ununited Fracture and False Joints.—Some bones, when broken, very rarely unite by bone, their fragments being kept firm merely by fibrous tissue, in some cases blended with the aponeurotic structures of the part, as is the case with the patella. This, which is owing to a want of apposition of the fragments, and is dependent on the anatomical relations of the part, cannot be considered a diseased condition.

It occasionally happens, however, in a fracture of the shaft or the articular end of a long bone, that proper union does not take place, and we get either Ununited Fracture or a False Joint.

In an **Ununited Fracture** the ends of the bone are rounded and the medullary canal closed by a thin plate of bone, which is sometimes hard and eburnated ; more often the ends are atrophied and somewhat pointed. They are merely connected by or enveloped in some loose fibrous tissue. Ununited fracture may arise in one of three ways ; 1, the fragments may be so widely separated that no uniting material could form ; 2, from various causes no uniting material, but loose fibrous tissue has been formed, and 3, true bony union has taken place, but owing to some peculiar state of the patient's health, the callus has become absorbed and the fracture loosened.

In **False Joint** there has usually been an abundant formation of the early soft reparative material preliminary to the formation of bony callus, but it has failed to ossify, and has become developed into more or less firm fibrous tissue, so that the ends of the bone are tied together by strong almost ligamentous bands. The structure of these false joints, which has been carefully studied by Rokitansky, presents two distinct varieties. In the first, which partakes of the character of a hinge-joint, we find that the ends of the fracture are smoothed and rounded, invested with a dense fibrous periosteum, and united to one another by thick bands of ligamentous tissue, in such a way as usually to admit of considerable lateral movement, though sometimes they are tolerably firm. In the other variety the joint partakes of the ball-and-socket character, usually to a very imperfect degree, but sometimes in a sufficiently well-developed manner—one end of the bone being rounded, the other cup-shaped, and both covered by a firm smooth fibroid tissue. The bones are united by a kind of capsule, in which a synovia-like fluid has occasionally been found.


Fig. 183.—False Joint in Humerus.

The form that the false joint will assume depends on the action of the muscles which influence it. Thus, when occurring in the shafts of long bones, where it is subjected to movements of flexion and extension, it will assume the hinge-form; whilst, when it is seated in the articular ends, where it is more subjected to movements of rotation, it will affect the ball-and-socket character.

Non-union of fracture, whether resulting in false joint or in ordinary ununited fracture, is undoubtedly very rare. I have very seldom met with it in my own practice. The cases that have been under my care at University College Hospital have almost all been sent up from various parts of the country, and probably present but a very small proportion of the fractures that have occurred in the districts from which they came. We probably exaggerate the frequency of non-union, if we say that it occurs in the proportion of one in a thousand cases of fracture of the limbs.

Causes.—The causes of ununited fracture and of false joint are *constitutional* and *local.*

In some cases the **Constitutional Cause** appears to be a *cachectic state* of the system occurring from some diseases, such as fever, scurvy, syphilis, or cancer, or from any depressing influence, in consequence of which there is a diminished reparative power. If callus have been formed, it may, under the influence of these constitutional causes, again become absorbed, and the fracture may thus be loosened. This is said to be especially liable to occur in scurvy. Mere debility, independently of some definite constitutional disease, will not lead to want of union in a fracture. In fact, in many very weakly children, fractures will unite with the greatest readiness; or if union be delayed for a short time it will, on the improvement of health, readily take place. Indeed, the causes that, independently of local conditions, lead to non-union of a fractured bone, are most obscure. In many cases no constitutional cause for the want of union can be detected, the patient being in

excellent health, strong, and robust. In spontaneous fractures, union seldom takes place very readily or perfectly.

Pregnancy is said to have a tendency to interfere with the proper union of a fracture ; this, however, I consider doubtful, as I have had under my care, and have seen, a considerable number of cases of fracture in pregnant women, which united in the ordinary time. Billroth has made a similar observation.

Age.—Failure of union in fractures is very rare in children, and when it occurs in them is seldom remediable, unless it be the result of neglect or of improper mechanical treatment. It is more common at the earlier adult and middle ages. Union will readily occur in aged individuals. Indeed, advanced age appears to exercise no adverse influence on the repair of fractures. I have on two occasions, in my own practice, known very firm and perfect consolidation of fracture of the shaft of the femur to take place in women of ninety years of age and upwards.

The **Local Causes** are various and important. The *anatomical condition* of the fragments, as regards their *vascular supply*, is perhaps that on which want of union is most immediately dependent. For proper union to take place, it is necessary that the callus be formed from both sides of the fracture. If one fragment be so situated that sufficient blood is not sent to it for this purpose, not only may want of union, but necrosis, occur. This is exemplified in fractures of the superior articular ends of the humerus and femur. In intra-capsular fracture of the anatomical neck of the humerus, the globular head, being detached from all its vascular connections, may necrose. In intra-capsular fracture of the neck of the femur, the head of the bone, still retaining some vascular connection through the medium of the ligamentum teres, has sufficient blood furnished to it to prevent its death, but not enough to form callus—hence fibrous union takes place. In the shafts of the long bones, the degree of union will be dependent in a great measure on the conditions of the vascular supply to the fragments, through the medium of the nutrient artery. The influence of rupture of the nutrient artery of a bone by the line of fracture running across it, and thus interfering with the vascular supply of one of the fragments, has been investigated by Gueretin ; and the occasional occurrence of atrophy of the bone after fracture, has been shown by Curling to be dependent upon the interruption of the supply of arterial blood through this vessel. He states that the portion of bone on that side of the foramen towards which the blood flows, being deprived of its proper vascular supply, undergoes certain changes ; the medullary canal becoming expanded and the osseous tissue less dense. Gueretin has collected cases that tend to prove the direct connection between the occurrence of ununited fracture, and the want of proper arterial supply to one of the fragments. Thus, in the humerus the course of the nutrient artery is from above downwards ; and of thirteen cases of ununited fracture, nine were found to be situated above the canal in which the vessel is lodged. In the fore-arm, where the nutrient artery passes from below upwards, of eight cases of ununited fracture, seven occurred below this vessel, and only one above. Adams, has, however, shown that the number and size, as well as position, of the arteries entering the bone, vary considerably ; and hence the objection that non-union may occur in a fracture of any part of the shaft of a long bone, whereas the nutrient artery is found only at one spot, can scarcely be considered a very valid one.

Some bones are much more liable than others to non-union of their fractures. According to the statistics collected by Norris, it would appear that the femur, the humerus, the bones of the leg, and of the forearm, and lastly the lower jaw, are those in which ununited fractures most frequently occur. Thus out of 150 cases, 48 occurred in the femur, 48 in the humerus, 33 in the leg, 19 in the forearm, and 2 in the lower jaw. This is quite out of proportion to the frequency of fracture in these bones; for, according to Bruns, of all fractures, 18 per cent. occur in the forearm, 15 to 16 in the leg, 7 in the humerus, and 6 in the femur. Hamilton states that in his experience the humerus is more commonly the seat of an ununited fracture than the femur; and my experience agrees with his.

One cause that may operate in leading to want of union in a fracture is the *application of a bandage* directly and too tightly to the limb. When this is done, the vascular supply to the broken bone is strangled, the muscles and soft textures want nutrition, and consequently, *à fortiori*, reparative actions are interfered with, and callus is not formed of proper consistence or in sufficient quantity for consolidation of the fracture.

The occurrence of ununited fracture is occasionally attributed to the *want of proper apposition* of the fragments which are so situated that instead of the broken surfaces being in contact, rotation of the limb has caused the outer and periosteal aspects to touch. Doubtless, in some cases, it may be so occasioned: but I believe that these causes are not nearly so frequent in their operation as the constitutional and local conditions that have already been pointed out. The *interposition of a piece of muscle* between the fragments may prevent union. Of this I saw an interesting instance some years ago, in which want of union in a fractured femur was owing to perforation of the vastus muscle by the upper fragment, and its entanglement between the broken ends. But it is very certain that, to whatever condition, local or constitutional, non-union of a fracture may be due, it is in very many cases quite impossible to assign to it any cause appreciable by the Surgeon.

In a certain proportion of cases variously estimated by different authors, the cause of non-union is *inefficient maintenance of rest* during treatment.

Compound fractures much more often fail to unite than simple; in many cases this is due to loss of bone by necrosis.

The **Treatment of ununited fracture** must not be conducted by local means only; *constitutional measures* should not be neglected. We cannot expect the formation of firm and strong callus unless the general health be in a satisfactory state. If callus have not been formed, or if, after formation, it have been absorbed under the influence of a cachectic state of the system, the improvement of the patient's health, at the same time that the fracture is put up again firmly, so that the ends of the bone are brought into close apposition, may bring about perfect union. In some instances of ununited fracture or delayed union in syphilitic subjects, union speedily takes place after the administration of some preparation of mercury or iodide of potassium, according to the stage of the constitutional affection. I have had under my care at the Hospital, a man with ununited fracture of the femur from absorption of the callus four months after the occurrence of the injury, under the influence of incipient phthisis and debility induced by want of food: perfect consolidation of the fracture was produced by giving him cod-liver oil and good diet, with rest in bed and a starched bandage to the limb. Hence it is evident that impaired

nutrition may prevent union, even after callus has been formed, and that improvement of the nutritive activity of the body may of itself lead to consolidation of the fragments. If there be no very evident cause for the want of union, it will occasionally suffice to put up the fracture firmly in leather or gutta-percha splints, with a starched bandage, or plaster of Paris, and then to allow the patient to move about upon crutches, so that his general health may not suffer, at the same time that a tonic plan of treatment is followed. I have seen several cases in which the want of union appeared to have resulted from too long confinement of the patient to his bed, and the consequent impairment of his health, consolidation taking place when a more favourable hygienic system was enforced. This simple plan can, however, be useful only if but a short time, at most some months, have elapsed from the occurrence of the injury. In some cases, the empirical administration of mercury is attended with success. In a case of ununited fracture of the humerus that was admitted into the University College Hospital under Liston, fifteen weeks after the occurrence of the injury, union was induced within a month by putting up the limb in splints, and salivating the patient. When the want of union arises from malignant disease, nothing can be done.

At the same time, with appropriate constitutional treatment, suitable *local means* must be employed to secure steady coaptation of the fragments. In the upper extremity, this may usually be done by means of splints of an ordinary character. In the leg, the starched or plaster-of-Paris-bandage will be found to be especially serviceable. Before putting the limb up in the plaster- or starched bandage, it is a good plan to *rub the ends of the bones forcibly* together, the patient, if necessary, being under the influence of an anæsthetic. In this way a certain degree of inflammation may be set up, which may be followed by a fresh formation of callus.

In the case of ununited fracture of the thigh, special apparatus will be required to secure complete fixity and steadiness of the limb. For this purpose, the limb should be put in an apparatus, consisting of an outer and an inner iron rod having hinge-joints opposite the hip and ankle, and attached above to a strong pelvic band, and below to the sole of the boot. The thigh part should be provided with well-padded splints, which may be screwed down in opposite directions against the two fragments, so as to hold them firmly in contact. This instrument should be worn for several months; and by it Smith, of Philadelphia, has succeeded in curing ten out of fourteen ununited fractures in the lower extremity. One great recommendation is, that this plan of treatment is entirely devoid of danger, and enables the patient to take exercise whilst under treatment. In cases where there are much shortening of the limb and riding of the fragments, which are especially apt to occur in the thigh, it will be necessary to employ extension of the limb as well as compression of the fragments against one another. This extension may be made by the lateral iron rods of the above-described apparatus being constructed so as to slide, by means of a rack-and-pinion- or screw-mechanism, by which the limb may be gradually lengthened to any required extent (Fig. 184).

When the failure of union has become very chronic, and a **False Joint** has been formed, it will be necessary to employ operative procedure before union can be attained. All operations that are undertaken in these cases are conducted on one of two principles; either, 1, *to excite such inflammation in the false joint* and the neighbouring tissues, as will lead to inflammatory exudation,

which, as in the process of union of a recent fracture, may be followed by the development of callus; or else, 2, *by removing the false joint altogether*, to convert the case into a recent compound fracture, and to treat it as such an accident. It can be easily understood that operative procedures conducted on these principles are too serious to be lightly undertaken, or to be had recourse to until other measures have failed, the mortality following them being, even according to published statistics, considerable, and probably very much greater than has been laid before the profession.

Fig. 184. — Apparatus for Ununited Fracture of Femur.

1. Among the first set of operations,—those that have in view the **Excitation of Inflammation**,—the simplest procedure consists in the **introduction of acupuncture needles**, or in the **subcutaneous section** of the ligamentous band with a tenotome. In this way I have known union effected in a patient of Liston's, who had a false joint in the shaft of the femur; though not until after the fracture had been converted into a compound one, and much danger and suffering incurred. Four years after the consolidation of the ununited fracture, the patient was readmitted into the Hospital, under my care, with fracture of the same bone two inches lower down than the former injury; on this occasion, union took place in the usual manner and time without any difficulty.

Percussion of the ends of the bones has been successfully employed in these cases by H. O. Thomas. The method consists in protecting the skin at the seat of fracture with a piece of felt, and then percussing forcibly the ends of the broken but ununited bone by means of a copper mallet. The percussion under anæsthesia may be continued for several —as many as ten—minutes; it may only be required once, or may need several repetitions. The effect is a good deal of local swelling and irritation. The limb should be put up firmly as for recent fracture, and a cure may be expected in from four to six weeks.

The **introduction of a seton** across the false joint, though occasionally successful, is apt to give rise to dangerous and even fatal results, from setting up septic suppuration deep in the limb, with very insufficient exit for the discharges, thus leading to extensive diffuse inflammation. If the seton be employed, these dangers might be diminished by the use of antiseptic precautions. The threads must not be left in beyond a few days, when sufficient action will have been induced. A modification of the seton consists in passing a silver wire around the fracture, and gradually tightening this, so as to cut through the false joint at the same time that inflammation is excited in it. In performing this operation, it must be borne in mind that large arterial branches, and even the main trunk, especially in the thigh, may become firmly attached to the callus, so that unless care be taken they may readily be wounded.

Dieffenbach has proposed to excite the requisite degree of inflammation by **driving, with a mallet, three or four conical ivory pegs** into holes bored by means of a drill into the ends of the fractured bone, which are

exposed for this purpose. The awl, or drill, may be worked with the Archimedean screw, and will then be found to penetrate much more easily (Fig. 185), but in the absence of this instrument, a common bradawl will do just as well. The soft parts are then to be laid down, and after a few weeks the pegs, which have loosened in consequence of the absorption of the surrounding bone, and also partly of the pegs themselves, should be taken out. It is not necessary or even desirable to attempt to pin together the ends of the broken bone, but merely to introduce the pegs into the extremities of both fragments near to the seat of fracture. It is especially in ununited fractures of the humerus that this can be successfully done, the irritation of the pegs appearing

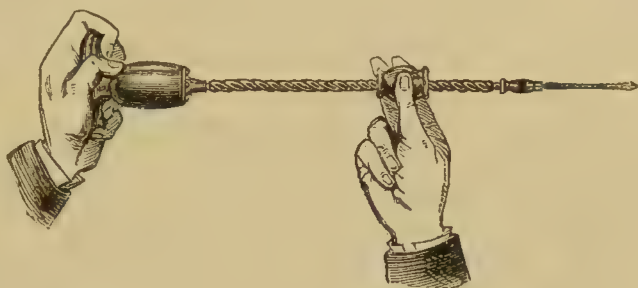


Fig. 185.—Archimedean Drill for perforating Bone.

to occasion the development of a large quantity of callus sufficient for the consolidation of the fracture. I have practised the operation with great success in several instances of ununited fracture of this bone. In one case under my care, there was a false joint at the junction of the upper and middle thirds of the bone, complicated with an elbow ankylosed in the straight position; here, after flexion of the stiff elbow, perfect consolidation of the humerus was effected by the use of five pins. In ununited fractures of the bones of the leg and forearm, it is also likely to be serviceable, but in the femur not so much so. Indeed, in the cases of ununited fracture of this bone, I have known more failures than successes after this operation.

2. The operation of *Removing the False Joint* is the last expedient when simpler means have failed. This operation was formerly extremely dangerous, and cannot now be regarded as anything but serious, especially where the femur is the bone to be operated on. By the proper use of antiseptics, however, and good drainage and rest after the operation, it may be robbed of most of its dangers. Norris collected thirty-nine cases, in which the ends of the bones were either resected or scraped; twenty-four were cured, seven derived no benefit, and six died. Erysipelas, phlebitis, and diffuse suppuration were the chief complications, all of which we can hope to prevent at the present time by the means above mentioned. The operation is thus performed: the false joint is freely exposed by an incision, so placed as to do the least possible injury to the surrounding soft parts. The periosteum is then carefully raised by means of a periosteal elevator from the part it is intended to remove. To facilitate the perfect exposure of the ends of the fragments, the fibrous tissue, forming the false joint, may be cut through if necessary. The end of one of the fragments being thoroughly cleaned, it must be sawn off obliquely, or, if more convenient, a chisel and mallet may be used to cut it through. As a rule, a smooth and more regular surface is obtained by using the saw. The

opposite fragment is then treated in the same way. The two bevelled ends are then brought into contact and wired together. To do this, a hole must be drilled obliquely from the surface of each into the medullary canal. A strong piece of thick, tolerably soft, silver wire must be passed through the holes, and the fragments drawn into accurate apposition. Sir W. Fergusson speaks highly of wiring together the ends of the bones. At the end of six weeks to three months the wires may be cut down upon and removed. Should they produce no irritation they may be left. Bickersteth, instead of using wires, splices together the freshened ends of the bone with iron pegs.

In all cases some shortening of the limb must necessarily result, but if solid union can be obtained, this is of but little consequence. In operating on the fore-arm or leg, if both bones are affected, care must be taken to remove an equal quantity from each. If the fracture be very oblique, the section of the bone must be in the same line, so as to cause as little shortening as possible.

Professor Nussbaum, of Munich, has successfully transplanted bone in a case where a portion of the ulna was lost as the result of a gunshot-injury.

Operations for ununited fracture rarely succeed when the disunion is owing to other than local causes. They may succeed in old people. I have united a femur disunited for twelve months in a man between sixty and seventy, by Dieffenbach's method. The more thickly the bone is covered by the soft parts, the more likely will an operation be successful. Hence, the humerus and femur are more favourable for operation than the tibia.

On reviewing the various methods that have been recommended for re-establishment of union between the separated fragments, it would appear that if the period of normal union has been exceeded by but a few weeks, rubbing the ends of the bones forcibly together, or percussion, may be tried, followed by the application of a plaster-of-Paris-bandage. Should this have no effect, further efforts may be made to excite a sufficient degree of inflammation by subcutaneous section and scraping of the ends of the fragments. Should this fail it is not advisable to pass a seton, as it is quite as dangerous a proceeding as one of the larger operations, and not so certain. The seat of fracture should therefore he cut down upon, and if it be found that there is firm fibrous union, the insertion of Dieffenbach's pegs might be sufficient, as if the proper amount of inflammation be set up, the intervening fibrous tissue becomes converted into bone; but if there is a distinct false joint, it had better be removed, and the bevelled ends tied together with wire. In such cases shortening to an extent corresponding to the overlapping of the obliquely cut ends must necessarily be left. If union should fail to be accomplished, much may be done to relieve the patient by properly devised apparatus, but if the false joint be situated in the femur or the tibia, the limb may be so useless and cumbersome to the patient, that amputation may be required as a last resource.

CHAPTER XXI.

SPECIAL FRACTURES.

In considering the nature and treatment of fractures of particular bones, we shall at present confine our remarks to Fractures of the Bones of the Face, Trunk, and Extremities. Injuries of the Bones of the Head and Spine derive their principal interest and importance from their complication with lesion of the contained organs ; hence the consideration of these will be deferred to special Chapters.

FRACTURES OF THE BONES OF THE FACE.

Nasal Bones.—These, being thin as well as exposed, are not unfrequently broken (Fig. 186). When fractured, they may remain undisplaced, but they are more commonly depressed; the ridge of the nose being beaten in. The swelling and ecchymosis that usually attend their fracture often render detection difficult, and must be reduced before any treatment can be adopted for

Fig. 186.—Fracture of Nasal Bones.

Fig. 187.—Spring-Clip for straightening the Nose.

the removal of the deformity. The depressed bone should be raised with the narrow end of a director, or by the introduction into the nostril of a pair of polypus-forceps, which, expanding on being opened, push the bone into proper position. To do this thoroughly it is often necessary to administer an anæsthetic. A flaccid vulcanized India-rubber dilator, of proper size and shape, introduced empty, and then expanded with water, will be found to answer admirably in restoring the shape, and removing the disfigurement of a "broken nose," even though some weeks have elapsed since the injury. Union of the bone takes place very rapidly. It is often moderately firm at the end of a week and solid in two weeks.

The nose without being exactly broken is often twisted to one side, more particularly if the organ be naturally long and pointed. This deformity alters completely the expression of the face, often producing a somewhat ludicrous appearance. When recent, and more especially when the patient is young, it may be remedied by the use of a spring-clip (Fig. 187), which presses the distorted end of the nose back to the straight line.

If the **septum** alone be broken, the same treatment must be adopted; the nose being supported and moulded into shape. As a rule, after it has been replaced, the position is maintained: but in some cases, where there is a tendency to sinking of the soft parts of the nose, the introduction of a plug of oiled lint round a quill, left open for breathing, will be required to replace and retain the organ in proper shape and prominence. The hæmorrhage, which is usually rather abundant in the first instance, may be stopped by the application of ice; but occasionally the nostrils require plugging, in order to prevent it from continuing to a dangerous extent. If the **lachrymal bone** be broken together with the nasal, the ductus ad nasum may be obstructed, and the course of the tears diverted. In an injury of this kind, I have seen extensive emphysema of the eyelids and forehead occur on the patient attempting to blow his nose. In some cases, the injury inflicted on the nasal bones extends through the ethmoid to the base of the brain, and may thus occasion death. This I have seen happen from a severe blow on the face with a piece of wood.

Malar and Upper Jaw-Bones.—These are seldom broken unless great and direct violence have been employed; and their fracture is usually accompanied by external wound, as in gun-shot injuries of these parts. More commonly the alveolar processes are detached, and the teeth loosened. The treatment then consists in binding the teeth together with gold wire. In fractures of the *zygoma*, the fragments may be driven into the temporal muscle, and produce so much difficulty in mastication as to require removal.

In some rare cases, **all the bones of the face** appear to have been smashed, and separated from the skull by the infliction of great violence. Thus, South relates the case of a man who was struck on the face by the handle of a crane, and in whom all the bones were separated and loosened, "feeling like beans in a bag." Vidal records the case of a man, who, by a fall from a great height, separated all his facial bones. A patient was admitted into University College Hospital under my care, who had fallen thirty feet over the balusters of a spiral staircase. He had in some way struck his face, either on reaching the ground or in the fall. He lived only about two hours after admission. On making a *post mortem* examination, the following injuries were found. The lower jaw was fractured through the ramus on the left side, and through the body between the molar teeth on the right side. In the upper jaw a transverse fracture ran completely across from one side of the face to the other, at about the level of the inferior border of the anterior nares. It passed through both superior maxillary bones, the vertical part of the palate bones, both pterygoid processes of the sphenoid bone on both sides, and the vomer; so that the whole of the alveolar portions of the superior maxilla and the palate formed one piece. This was displaced backwards into the pharynx. The zygoma was fractured on both sides; and a vertical fracture ran on each side from the margin of the orbit through the walls of the antrum; so that on each side there was one huge fragment composed of part of the zygoma, the malar bone, and the part of the superior maxillary bone with which it is articulated. The nasal bones, the nasal processes of the superior maxillary bones, the os unguis on each side, and the ethmoid, were smashed into numerous small fragments. There was no fracture visible from the interior of the skull; and no other injuries of importance were found.

In another case the patient falling out of a third-storey-window struck the

face against the out-railings. The superior maxillæ were broken across transversely above the line of the teeth. So that these and the hard palate could be gently turned backwards and forwards. This patient died from a splinter of the sphenoid bone having penetrated the dura mater.

But I have known several cases of transverse fracture of one superior maxillary bone do well. In such cases the aid of the dentist is required to tie together the teeth, or to fix the displaced fragments by means of suitable vulcanite moulds. The question of feeding the patient is usually one of difficulty, and the food often requires to be introduced by means of the stomach-bottle.

In **Gun-shot-Injuries of the Face**, there is usually great splintering of the bone. As, however, the vitality of the part is great, necrosis is not so likely to ensue here as elsewhere ; and the partially detached and loosened fragments may accordingly be put back into position, and will usually become fixed. There are, however, two principal dangers in these cases ; viz., hæmorrhage, either primary or secondary, and abundant fetid muco-puriform discharge. The hæmorrhage, when primary, usually ceases spontaneously, or on the application of cold. If secondary, it may be arrested by cold, by plugging, and by pressure ; or, if continuous, and from deep sources, it may possibly require ligature of the carotid. The fetid secretion from these wounds is not only a source of great discomfort to the patient, but of positive danger, as, by finding its way into the stomach it may seriously disturb the patient's health; and, drainage being difficult, he may also suffer from absorption of the septic matter from the raw surface. This risk is best obviated by repeated injections of warm antiseptic solutions, of which the solution of permanganate of potash or boracic acid is the best. Whenever it is possible to reach the raw surface in any way, it must, after it has been well washed, be dusted over with iodoform. This exerts a far more powerful and lasting antiseptic influence than any lotion.

LOWER JAW.—This bone is frequently broken, owing to its prominent situation ; though its arched shape and great strength enable it to resist all but extreme degrees of violence.

All fractures of this bone which implicate the alveolar border are necessarily compound, the laceration of the gum causing them to communicate with the external air. In other cases an external wound, as in gun-shot fractures, may communicate with the fracture. Not unfrequently they are comminuted.

Fracture of the lower jaw may occur in various situations. I have seen it most frequently in the **body of the bone** near the symphysis, extending between the lateral incisor and the canine teeth. The **symphysis** itself is not so commonly fractured, the bone being thick in this situation. The **angle** is more frequently broken. The **coronoid process** can suffer fracture only from the most severe and direct external injury, as from a bullet-wound. The **neck of the condyle** is occasionally broken across.

Fractures near the symphysis are usually vertical. Those near the angle are commonly oblique from before backwards, so that a long spiculum of the outer table is connected with the upper fragment.

These fractures are sometimes double: either symmetrically so, or, more frequently, one on the side near the symphysis, and the other near the angle.

The **Signs** of fracture of the lower jaw are very obvious. The great mobility of the fragments, the crepitus, the irregularity of the line of teeth and of the arch of the jaw, laceration of and bleeding from the gums, and

dribbling of saliva, indicate unequivocally the nature of the injury. The displacement and mobility of the fracture are greater, the nearer it is to the symphysis. If the bone happen to be broken on both sides of this line, the middle fragment is much dragged out of place by the depressor muscles attached to it; indeed, in all double fractures the displacement is very great. In fracture about the angle and lower part of the ramus, the deformity is not so great, owing to the muscles that coat and protect each side of the bone in this situation preventing the fragments from being displaced. When the neck of the condyle is broken through, that process is often much displaced by the action of the external pterygoid.

When the fracture is near the symphysis, the dental canal escapes; but when it is further back in the body of the bone, and especially near the angle, the canal must necessarily be implicated. It is remarkable, however, that the inferior dental nerve usually escapes injury or division in many cases altogether, in others for several days, until, perhaps, owing to great displacement or to some effort in reduction, it may be torn across. When this happens, the soft parts of the lower lip, supplied by the mental branch of the inferior dental, are necessarily for a time deprived of sensation, but they soon recover. I have never known any permanent mischief from this cause, nor from the hæmorrhage following laceration of the inferior dental artery.

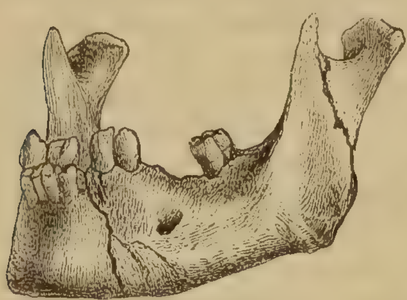


Fig. 188.—Fracture of Lower Jaw.

The **Treatment** is simple enough in principle, though often not very easy of accomplishment. It consists in maintaining the parts in apposition by suitable

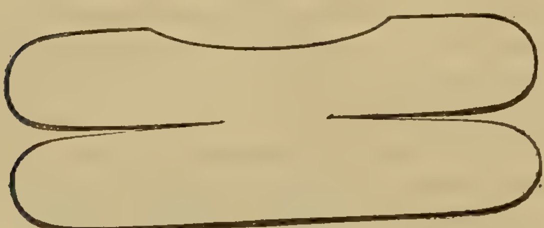


Fig. 189.—Gutta-Percha-Splint: Original Shape.

Fig. 190.—Gutta-Percha-Splint, moulded to Shape of Jaw.

apparatus for four or five weeks, during which time mastication must be interdicted—the patient living on sops, soups, and fluid nourishment of all kinds—and talking prohibited. The apparatus that commonly suffices consists of a gutta-percha splint (Fig. 189), moulded to the part (Fig. 190), lined with lint, and fixed on with a four-tailed bandage; the two fore-ends of which are tied behind the neck, whilst the other two are knotted over the top of the head (Fig. 191). When the ramus is broken, the side of the gutta-percha splint should be made proportionately long. The teeth in these cases require special attention. Any that are loosened must be left in, as they will soon contract adhesions, and fix themselves firmly; and, if necessary, they may be tied to the sound teeth with silver wire, or dentist's silk. Care must be taken that any tooth that may have been forced out of its alveolus and dropped between the fragments be removed from this situation; in one case

where a tooth was overlooked in this position, no union of the fracture took place till it had been removed. When depression, especially near the symphysis, is considerable, a clamp apparatus which fixes the chin and line of teeth, invented by Lonsdale, answers the purpose of steadying the frag-

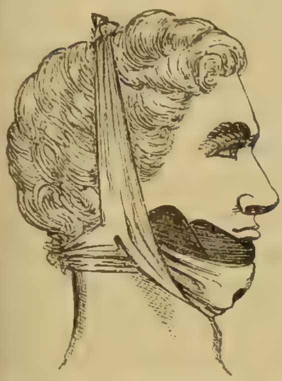


Fig. 191.
Apparatus applied to Fracture of Lower Jaw.

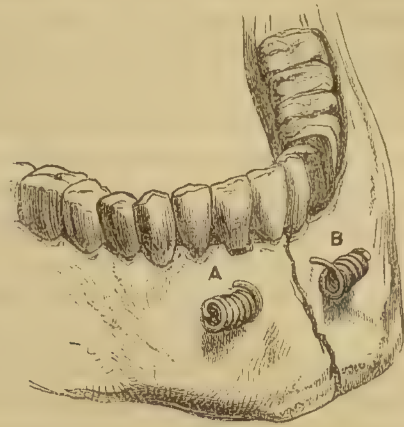


Fig. 192.
Thomas's first method of uniting Fracture of the Lower Jaw. A. B. wires passed through drill-holes and coiled by the key, Fig. 193.

Fig. 193.

ments extremely well. When the fracture is double, one fissure occurring near the symphysis, the other near the angle, there is often very considerable difficulty in bringing the fragments into anything like good position, without the aid of some special apparatus. In such cases a cast should be taken of the teeth in gutta-percha, while the fragments are held in accurate position, and from this a metal plate should be modelled, fitted to the teeth, and attached to Lonsdale's clamp or to a stem, and fixed to a horse-shoe-shaped splint placed under the jaw, so as to keep the whole steady and solid. Union generally takes place readily and very perfectly in fractures of the jaw, though it is somewhat slow at first, and the fragments continue mobile for some weeks. But the vascular supply of the bone is abundant, and reparative action correspondingly perfect.

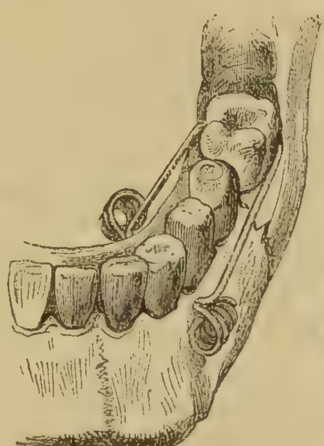


Fig. 194.—Thomas's second mode of uniting Fracture of the Lower Jaw by twisted and coiled wire.

Fig. 195.—Form of the coil of wire.

The cure is often delayed by the separation of necrosed fragments. If there should be any offensive discharge the patient must wash out his mouth with Condy's fluid and water, after which iodoform must be sprinkled on the wound.

In all compound fractures of the lower jaw, H. O. Thomas strongly advocates drilling the bone on each side of the fracture, and fixing the fragments

by means of thick pliant silver wire. He finds that the ordinary cross-twist does not hold; he therefore coils the wire at each side (Figs. 192, 194). In order to facilitate this operation, he has devised a set of instruments, comprising a tubular needle to return the wire, and a key for coiling it (Fig. 193).

In **Fractures of the Body of the Lower Jaw by Gun-shot Injury**, there is great comminution and splintering of the bone, followed by copious and fetid discharge, which, being in part swallowed, may reduce the patient to a state of extreme debility, or may even prove fatal. The free use of disinfectants, and especially of iodoform, will however do much to counteract this. In extreme cases, Dupuytren recommends the lower lip to be cut through, the splinters taken away, and, if necessary, a portion of the bone resected, so as to convert the wound into one similar to that which results after the partial removal of the lower jaw for disease of the bone.

FRACTURE OF THE HYOID BONE is of very rare occurrence; and, though usually the result of direct violence, as a forcible grasp, has been seen by Ollivier D'Angers to occur from muscular action. The signs are always very obvious. The fragments form a sharp salient angle: there are much pain and irritation, increased by speaking and deglutition. There is usually salivation; and considerable difficulty in breathing may be present. *Reduction* is accomplished by pressing the fragments into position, either externally or by passing the finger into the mouth. Should one piece of the bone be driven much in, it might possibly require to be drawn forwards with a tenaculum. The neck should then be fixed with a stiff pasteboard collar to prevent displacement.

FRACTURES OF THE BONES OF THE CHEST.

FRACTURE OF THE RIBS AND COSTAL CARTILAGES.—These injuries may occur in two ways: 1st, from direct violence, the part that is struck being driven in towards the thoracic cavity, and thus broken; 2nd, the fracture occurs from indirect violence, the forepart of the chest being forcibly compressed, so that the rib is bent outwards, and snaps. When the injury is the result of direct violence, and the broken fragments are forced in, the pleura, lung, liver, or diaphragm, may be wounded, thus giving rise to the most serious and fatal consequences, such as hæmorrhage, emphysema, and inflammation of the parts injured. When it is occasioned by indirect violence, as the fracture takes place in a direction outwards, the thoracic organs may be contused, and thus injured, but they are not liable to be punctured by the fragments. In some rare cases, the ribs have been known to be broken by the violent contraction of the abdominal muscles during parturient efforts.

Fractures of the ribs may be *single*; *multiple* when several, or even the whole of the ribs on one side, or several on both sides, are fractured; *simple*, as in ordinary violence; and *compound*, as in gunshot injuries; or when the broken ends are driven into the lung.

Any one of the ribs may be broken, and frequently several are fractured at the same time. The middle ribs, from the fourth to the eighth, are those that most frequently give way, being most exposed, and at the same time fixed. The first and second ribs are seldom broken, being protected by the clavicle and shoulder. When they are fractured it is usually the result of gunshot-violence, or, if from some of the ordinary accidents of civil life, the clavicle will be broken as well. But this is not an invariable complication. I have seen fractures of

the first two ribs from a fall, without any injury to neighbouring bones. This fracture is always very dangerous, on account of the liability to injury of important subjacent structures. The lower ribs, being less firmly fixed than the others, commonly escape, unless very great and direct violence be inflicted upon them. Any part of a rib may be broken by direct violence ; but when the fracture is the result of compression of the chest, it is usually the point of greatest convexity or the neighbourhood of the angle of the rib that gives way. These indirect fractures commonly occur in elderly people, in whom the elasticity of the thoracic parietes has lessened as the result of age, and they are peculiarly liable to occur in some cases of general paralysis of the insane, in which the bones are weakened by atrophy.

Symptoms.—The chief symptom is a sharp pricking and catching pain at the seat of injury, increased by breathing deeply, or by coughing. In order to avoid this, the inspirations are shallow, and the breathing is principally diaphragmatic and abdominal. On placing one hand on the sternum, and the other on the spine, and pressing gently, the patient will complain of pain at the seat of fracture. This is often a valuable means of diagnosis. On laying the hand over the seat of injury, and desiring the patient to cough, crepitus may often be felt ; and in most cases this is audible on applying the ear to the chest. The diagnosis of the fracture is necessarily more easily made where the ribs are thinly covered, than where they lie under the muscles of the back. Occasionally the outline of the rib will be found to be irregular; and in some instances, where several ribs are broken, the whole side of the chest is flattened and depressed. Besides these local symptoms, special complications resulting from laceration of the pleura and lung, such as hæmoptysis, pneumothorax, or emphysema, may occur. These complications, which will be fully described in the Chapter on Injuries of the Chest, are much less frequent than might *à priori* be supposed, owing to the fracturing force being usually indirect, causing the rib to bend outwards, and thus to break away from, instead of into, the chest. *Per se* a fractured rib is in no way dangerous. It is only when the fractured ends are driven inwards, so as to wound the deep parts, that danger arises. Hence the prognosis will mainly depend on the mode of occurrence of the fracture. If this be the result of a direct blow on the chest, as the kick of a horse, the fractured ends will be driven inwards, and so may do much mischief. The danger of fractured ribs, indeed, depends wholly on the thoracic complications, and these will be occasioned chiefly by one of two conditions: either by the forcible driving in of the fractured end of one rib, so that the pleura and lung become wounded by the sharp and ragged fragment; or else by a large number of ribs being broken by a severe squeeze of the chest, and the thoracic organs injured by the general compression. It is surprising, however, what an extent of injury of this kind may take place without serious consequences. I have had under my care a young man, who, in consequence of a crush of the chest, in a railway accident, had the upper seven ribs broken on the right side, and the lower five on the left, the chest, especially on the right side, being greatly flattened; he recovered without a bad symptom. In gunshot-injuries of the chest, with splintering of the ribs, there is always wound of the contained organs, which becomes the main source of danger to the patient and of attention on the part of the Surgeon.

Treatment.—In treating fractured ribs, the Surgeon need not concern

himself so much about the union of the fracture, as about the prevention of pain to the patient in breathing, and of the subsequent occurrence of serious inflammation or other mischief within the chest.

Any displacement that may exist usually remedies itself. The chest-wall, even when extensively flattened, gradually expands under the influence of the respiratory movements. If, however, a portion of the rib continue depressed, it had most certainly better be left so: the suggestions that have been made for elevating these fractures by means of sharp hooks and screw-probes, being more likely than the continuance of the depression to occasion serious mischief to the contents of the thorax. In order to prevent undue motion of the broken bone and consequent irritation produced by its puncturing the pleura, or lung, the movements of the injured part of the chest may be restrained by the application of a broad flannel-roller, or of a laced napkin round it. Instead of, or in addition to these means, it will be found most useful to apply a roll of adhesive plaster round the chest. The plaster must be about a foot in width, and should be sufficiently long to make one and a half turns round the body. It should be applied very tightly, and may be left on for ten days or a fortnight, when it may require re-application. It supports the chest more firmly and evenly than an ordinary bandage, affording the patient great comfort. If only one rib is fractured, and the patient is suffering but little pain, it will be enough to apply the strapping to the injured side only. A sufficient number of broad strips, each long enough to cover the injured side and to reach about two inches beyond the middle line in front and behind, may be firmly applied overlapping each other for about half their width. In some cases, however, more particularly in those in which the fragments are driven inwards, it will be found that the constriction of the chest, by bandage or plaster, becomes unbearable, producing great pain and intense dyspnœa. In these circumstances, all constriction must be removed, and the patient be allowed to breathe easily, but he must be confined to bed. If the lower ribs be broken, the diaphragm may become irritated by the projection inwards of the fractured bone; and if the plaster and bandage be applied too tightly, spasmodic action of that muscle may ensue, occasioning distressing hiccup and dyspnœa.

The **average period of union** of a fractured rib is three weeks. There is always a considerable amount of callus thrown out in the repair, on account of the constant movement that necessarily takes place between the broken ends in respiration.

In **gun-shot-injuries of the chest, with splintering of the ribs,** all broken spicula of bone must be carefully picked out, and the wound cleaned with an antiseptic lotion when possible. It must then be covered by carbolic gauze, iodoform, or salicylic wool, or some other efficient antiseptic application. In such cases, the grave injuries usually sustained by the intrathoracic organs will absorb the Surgeon's attention; and for their treatment I must refer to Chapter XXVIII.

It occasionally happens that fracture of one or more of the **Costal Cartilages**, especially the fifth, sixth, seventh, or eighth, is produced by direct violence. They may be separated from their junction with the rib, or broken across the middle. The existence of fracture may be determined by the pain on pressure, mobility, and irregularity at the seat of injury. The same treatment is required for this fracture as for a broken rib; the broken cartilage

most commonly uniting by a bony callus which surrounds the fractured ends.

Fracture of the Sternum.—The sternum is not often broken. Its fracture occurs usually from very severe and direct violence; and when this is applied on the forepart of the chest, the ribs or costal cartilages are more liable to suffer. The elastic support furnished to the sternum by these structures, explains in a great measure the rarity of its fracture. It may also be produced by violent bending forward of the body after the spine has been broken. It has been known to be broken, though very rarely, by violent straining muscular efforts during parturition. Its fractures are always transverse, usually single, but sometimes multiple. I have seen it broken into three nearly equal fragments by a fall from a scaffold. The displacement of one of the fragments is sometimes considerable, the upper fragment being almost invariably behind the lower; but even if there be but little deformity, the very superficial situation of the bone will always enable the Surgeon to judge of the exact nature of the injury it has sustained, the signs of which resemble those of a fractured rib.

The **Treatment** must be conducted on the same principles as in a broken rib, and presents nothing deserving of special attention. Indeed, when fracture of the sternum occurs from external violence, it is commonly associated with fracture of the ribs, near the angles; and then the chest-bandage or plaster answers equally for both injuries. Should the sternum be broken during parturition, the patient should be made to sit up in bed, with the shoulders supported and leaning forwards slightly, so as to take off the tension of the abdominal muscles. If a portion of broken sternum be depressed, it should be left undisturbed. It will probably give rise to no serious inconvenience, while any attempt to raise it by surgical interference might be attended with the greatest danger.

FRACTURES OF THE UPPER EXTREMITY.

Fractures of the upper extremity may occur from direct or from indirect violence. When from *direct* violence any portion of any bone from the tips of the fingers to the trunk may be broken. But indirect violence is the more common cause of such fractures; and the portion of the bone broken will depend on the way in which the violence is directed. Thus, when a person falls forwards on the palm outstretched to save him, the lower end of the radius is the part that usually gives way; or, if it be a child, the lower epiphysis of the humerus may be detached. If the elbow strike the ground, the shaft of the humerus at its junction with the upper epiphysis, gives way; and if the shoulder, the clavicle usually snaps across at its greatest convexity.

The Clavicle is more frequently broken than any other bone in the body, except the radius. For this there are three reasons. First, it is exposed to the influence of direct violence; secondly, it receives all shocks transmitted through the shoulder in a horizontal direction to the trunk; and, thirdly, being the only direct osseous support of the upper extremity, it receives, by transmission through the scapula, every shock that is communicated to the hand when the arm is extended. Notwithstanding its exposed position, it is comparatively seldom broken by direct injury. The great majority of the fractures occur from indirect violence, as falls on the shoulder and the hand. This bone would be more frequently broken than it is, were it not that it resembles two segments of a circle looking in opposite directions, so as

to form an S-shape, which admirably enables it to withstand indirect violence (Fig. 196).

The clavicle is occasionally fractured by muscular action—more particularly from the swing of the arm, as in a back-handed blow. When the accident occurs from this cause, it is usually about the middle of the bone, and on the right side.

Compound fracture of the clavicle can occur only from bullet-wounds, or some similar severe and direct injury inflicted upon the bone. Fractures from direct violence are usually transverse, and often comminuted; from indirect violence they are oblique. The latter are attended by much more deformity than the former.

Fractures of this bone in infants and young children are usually transverse; sometimes the bone is merely bent, or is fractured on one side only. The injury is usually occasioned by falling out of bed. Such accidents are frequently overlooked by careless nurses; but the child's crying whenever the arm is moved directs attention to the part, and the Surgeon then finds some deformity, with a node-like swelling about the middle of the bone.

Both clavicles are occasionally, though rarely, fractured. In one such case, which was under my care at University College Hospital, the patient, a young man of 20, had sustained this injury, and had twelve ribs broken as well, in a railway accident. Notwithstanding this serious complication, he made an excellent recovery.

Complications.—In simple oblique fracture of the clavicle, there is rarely any complication of importance. But when the fracture is the result of direct violence, the same force that breaks the bone may seriously injure subjacent parts of importance. The subclavian vein may be compressed or wounded, or the brachial plexus of nerves may be compressed or torn; the first rib may be broken by the crushing violence, and the pleura wounded.

The clavicle may be fractured at any point between its acromial and sternal ends. 1. Most frequently the **Great Convexity** is broken; the bone bending here when pressed upon from its extremity, the curve becoming increased, and at last giving way. This fracture may arise from direct violence, but usually is the result of falls on the hand or shoulder. 2. It may be fractured nearer the acromion, between the two **Coraco-clavicular Ligaments**. 3. Its **Outer End** may be broken off externally to the outermost point of insertion of the trapezoid ligament, between it and the acromion. These latter two fractures can scarcely occur from indirect, but are almost always the result of direct violence. 4. The clavicle may be broken internally, that is, to the **Sternal Side of the Rhomboid Ligament**, usually about three-quarters of an inch from its sternal articulation. This injury is of very rare occurrence. R. W. Smith, although admitting its possibility, states that there is no actual proof, from dissection, of its having occurred.

The **Signs** will depend upon the seat of fracture. When the bone is broken *between the conoid and trapezoid ligaments*, there is little, if any, displacement, but pain on pressure, some crepitus on moving the shoulder, and slight irregularity in running the finger along the bone, are usually present. When the fracture is *external to the trapezoid ligaments*, there is a remarkable displacement of the scapular fragment, the articular surface of which is turned forwards and inwards, with a slight inclination downwards, nearly at right angles to the rest of the bone, apparently by the dragging of the weight of

the shoulder, the point of which is rounded forwards (Fig. 197). When the fracture occurs *about the middle of the bone*, or at any part on the *sternal side of the scapular ligaments*, there is a well-marked deformity, owing to a triple displacement of the inner end of the outer fragment inwards, downwards, and slightly backwards, while the outer end is rotated forwards. This displacement is due to two causes, one of which is mechanical and the other muscular. The displacement downwards is due chiefly to the weight of the arm, but the contraction of the deltoid also would aid in depressing the inner end of the outer fragment. The displacement inwards is due to the action of the muscles passing from the chest to the arm and scapula, the pectoralis major and minor, and the latissimus dorsi; the rotation forwards and the pointing of the sternal end of the outer fragment backwards is due to the more powerful action of the pectoral muscles. The outer extremity of the inner fragment appears to be elevated, the skin being drawn tensely over it; but this is owing rather to the depression of the outer portion of the bone; it is usually kept fixed by the antagonism between the sterno-cleido-mastoid and great pectoral muscles. It may, however, in some cases be raised. This is when the clavicular portion of the sterno-cleido-mastoid muscle is unusually strong, and when the fracture has taken place just outside its insertion into the clavicle; or it may be raised and pushed forwards, by the inner end of the outer fragment getting below or behind it. On looking at a patient with fracture of the clavicle in this situation, the nature of the injury is at once evident. The approximation of the point of the shoulder towards the sternum; the prominence formed by the outer end of the inner fragment, over which the skin is stretched; the sudden depression under this, and the crepitus, which can be easily induced by elevating and rotating the shoulder at the same time that the elbow is pressed to the side, indicate in the most unequivocal manner the nature of the injury. The attitude of the patient is remarkable; he sits, leaning his head down to the affected side, so as to relax the muscles, and supports his elbow and fore-arm in the sound hand, in order to take off the weight of the limb; he is unable to raise his arm from the side, and any attempt to do so causes severe pain.

Fig. 196.—Sound Clavicle.

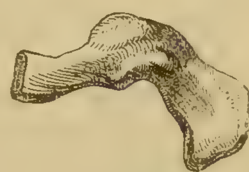


Fig. 197.—Fracture of Clavicle, outside of Trapezoid Ligament.

When the fracture occurs near to the sternal end of the bone, it is usually, if not always, transverse. If it occur internally to the rhomboid ligament, the outer fragment is displaced forward, but remains on the same horizontal level as the sternal fragment. If the triple displacement of the outer fragment, characteristic of fractured clavicle, viz., in a direction downwards, forwards, and inwards, have occurred, then R. W. Smith believes that, however near the joint the fracture may appear to be, it must in reality have occurred externally to the costo-clavicular ligament, which is too strong to admit of this displacement, or to be ruptured, and so to allow it to be occasioned.

In ordinary simple fracture of the clavicle the blood vessels passing under the bone are very rarely if ever injured or even compressed. This is owing to the manner in which the outer fragment is displaced, its sternal end being pushed in front of them and to their inner side.

Comminuted Fracture of the Clavicle is the result of severe and direct violence. It is a dangerous accident, as the subclavian vein and adjacent plexus of nerves, or the upper part of the pleura, may be seriously injured. In a case that was under my care, the subclavian vein was apparently wounded, great extravasation of blood taking place about the shoulder and neck, and the circulation through the veins of the arm being so much interfered with as to threaten gangrene. The case, however, did perfectly well under the continuous application of evaporating lotions to the shoulder, and attention to the position of the arm. But in another case, gangrene of the arm took place, leading to amputation at the shoulder-joint. The patient died of pyæmia, and a fragment about one inch long separated from the posterior part of the clavicle was found lying upon, and compressing, the subclavian vein.

Dr. John Ogle relates a case of comminuted fracture of the clavicle from direct violence, in which the right internal jugular vein was lacerated by one of the fragments, there being great extravasation of blood.

I have known only one instance in which the subclavian artery was injured. It occurred at University College Hospital. The left clavicle was broken by direct violence, a cart-wheel passing over the shoulder. An aneurism rapidly formed in the subclavian artery, whether by direct injury or as the result of severe strain was however uncertain. C. Heath, under whose care the patient was, amputated at the shoulder-joint.

Compound Fracture of the Clavicle can of course be produced only by direct violence, and in such cases any amount of injury may be done to the sublying and neighbouring parts by the same violence that breaks the bone or by fragments driven in. The vein, artery, or nerves may be injured, and their liability to injury will, for obvious anatomical reasons, be in the order named.

Treatment of Simple Fracture of the Clavicle.—There are few fractures for the cure of which so great a variety of ingenious and complicated contrivances has been devised, as those of the clavicle, and there are few in which so much ingenuity has been displayed in vain; for, however perfect the apparatus may appear to be, it seldom answers the purpose intended, viz., to cure the fracture without deformity. I believe that more may be done with a little skill and patience by simple means, than by the most elaborate mechanical contrivances.

When the fracture occurs at the tip of the acromial end of the clavicle, a figure-of-8-bandage round the shoulders, and keeping the arm in a sling, will prevent the tendency to rotation of the shoulder forwards. When the bone is broken between the coraco-clavicular ligaments there is but little displacement and the same treatment will suffice.

But when the fracture is situated towards the middle of the bone, or indeed at any point to the inside of these ligaments, the management is more difficult, and numerous methods of treating it have been invented. The objects aimed at in all are to draw the outer fragment outwards, to force its outer end backwards, and by supporting the weight of the limb to correct the displacement downwards. It is impossible to mention here more than the few methods of treatment that seem most practically useful.

Treatment by the Pad in the Axilla.—In this method the three principal indications are thus carried out.

1. By making a fulcrum of a thick wedge-shaped cushion with its broad end

upwards in the axilla, and then bringing the elbow closely to the side, the humerus is made to act as a lever and draw the shoulder and the scapular fragment outwards, thus correcting the displacement inwards. 2. By pressing the shoulder well backwards, behind the lateral median line of the body, the tendency to rotation forwards is removed. 3. By elevating the shoulder, and taking off the weight of the arm by means of a short sling that passes well under the elbow, the displacement downwards is remedied. By these simple means the triple displacement of the outer fragment is corrected. But the great difficulty consists in keeping the fracture in a good position ; and when it is oblique, this becomes almost impossible, so that a cure without nodular or angular deformity is very seldom obtained.

I used formerly to recommend that the fingers should be bandaged separately, the palm padded, and the bandage carried up as high as the axillary pad. More extended experience leads me to doubt the expediency of all these directions, and I now content myself with simply bandaging the hand and fore-arm lightly and leaving the tips of the fingers free, so that the conditions of the circulation through the limb can be watched. Care must be taken not to use the lever-like movement of the arm against the fulcrum of the axillary pad too forcibly, lest the axillary vessels or plexus of nerves be compressed. Before applying the roller, the elbow must always be flexed : otherwise undue and dangerous constriction of the arm may occur. The pad should be firm, made of bed-tick stuffed with bran, six inches long, five broad, and three thick at its upper part ; the sling must support the elbow, and the hand should be well raised across the chest. After the limb has been put up, the pulse at the wrist should be felt, and the finger-nails examined in order to see that the circulation is neither arrested nor impeded by the pressure of the pad. In the accompanying figure, the sling does not extend under the elbow as it ought to ; it is represented in this way, in order not to conceal the other parts of the apparatus (Fig. 198). The elbow must be kept to the side by a few turns of a roller, or by means of a padded belt.

Fig. 198.—Apparatus for Fractured Clavicle.

Treatment by the figure-of-8-Bandage.—If in a case of fractured clavicle the patient be seated in a chair, and the Surgeon, standing behind him, places his knee between the scapulæ, and holding by the points of the shoulders pulls forcibly backwards, the outer fragment will be seen to be drawn outwards at the same time that the rotation forwards is corrected. The treatment by the figure-of-8-bandage is intended to maintain this position while the weight of the arm is taken off by a sling supporting the elbow. The simplest form of this apparatus, and one that will frequently be found very useful as an immediate application, is that recommended by Syme, known as the *treatment by the three handkerchiefs.* A large handkerchief folded diagonally till it is about one inch and a half wide is placed round each shoulder so that it shall lie in front in the hollow internal to the coracoid process. The two ends are secured by a single turn behind the shoulder, and then twisted together so as to form a single cord. These cords are then knotted firmly together in the middle line, while the shoulders are forcibly pulled back-

wards; a folded towel must be put along the spine to prevent the knot hurting the patient. The third handkerchief is then put on as a sling firmly supporting the elbow.

Sayre's Treatment by Adhesive Plaster.—Lewis A. Sayre of New York recommends the following mode of treatment, which has been found to act extremely well during the last few years at University College Hospital.

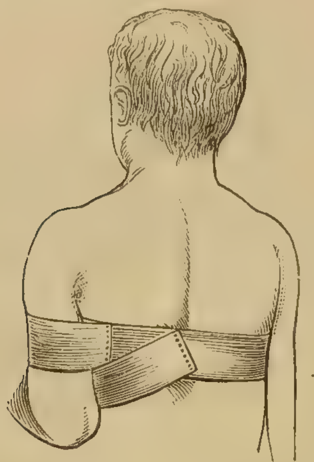


Fig. 199.—Strap drawing back Shoulder.

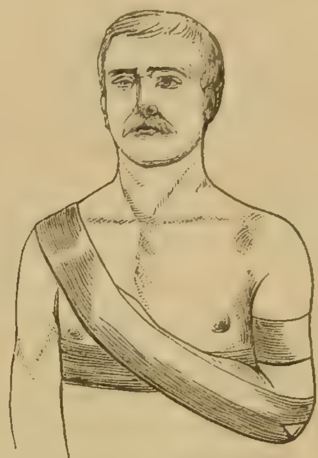


Fig. 200.—Strap raising Shoulder.

Two strips of plaster, spread on strong calico or moleskin, are to be cut, each about three and a half inches wide or less, according to the size of the patient. One of these is to be long enough to encircle the arm, and afterwards to pass one and a half times round the body. A loop in this is first passed round the arm immediately below the axillary border. The non-adhesive side of the plaster must be towards the skin, and the loop must be secured by stitches. It

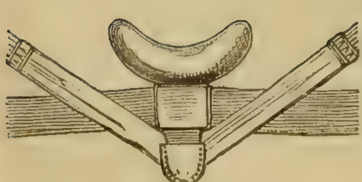


Fig. 201.—Ellis's Splint.

Fig. 202.—Ellis's Splint applied.

must be quite loose, so that there shall be no risk of compressing the vessels. When this has been made fast the elbow must be drawn well *backwards*, and the strip of plaster is carried firmly round the body and its end brought up and secured as in the figure. A few stitches may be inserted to render its hold more secure (Fig. 199). The second strip must be of sufficient length to

pass from the sound shoulder, obliquely round the chest beneath the elbow of the injured side, and to overlap for some six or eight inches. A slit must be cut in it for the olecranon. Before applying this the elbow must be drawn well *forwards*, when, the first strip of plaster acting as a fulcrum, the shoulder will be thrown backwards and outwards. At the same time the elbow must be forced upwards. These positions must be maintained by the application of the plaster over the forearm and hand, as in Fig. 200.

Ellis's Splint, which is sufficiently explained by the accompanying figures (Figs. 201, 202), though an unnecessarily cumbersome contrivance for ordinary cases of fractured clavicle, is useful in those instances in which great steadiness of limb is required to keep the fragments in good position.

In children, in whom these fractures often occur, there is frequently a difficulty in keeping the bandages properly applied ; in these circumstances the starched apparatus will be found very useful, care being taken to re-apply it as often as it becomes loose, lest deformity result. Fractured clavicles occurring in females, to whom any irregularity of union in this situation would be very annoying, are best treated by keeping the patient lying flat on her back in bed, with the arm fixed to the side, for the first two or three weeks. By this plan, which is as old as the days of Hippocrates, I have seen better results produced than by any other.

When *both* clavicles are broken, the patient should be kept in bed, and the shoulder fixed and drawn backwards by means of a figure-of-8-bandage. In the case already alluded to (p. 562), this could not be borne, owing to the simultaneous fracture of the ribs ; but the patient nevertheless made a good recovery with little deformity.

In **Comminuted Fracture of the Clavicle,** it must always be remembered that the subclavian vein may be compressed or contused. It is, therefore, of importance to avoid all means that may interfere with the return of venous blood from the arm. Hence the bandaging of the fingers, hand, and fore-arm should be omitted, and the axillary pad laid aside. The limb should be drawn back, supported in a sling, and the patient kept recumbent until union has been attained.

In comminuted simple fracture of the clavicle with vertical depression of the central portion, Annandale has removed the displaced piece of bone.

Period of Union.—In adults a fractured clavicle is solidly united in four weeks. In children three weeks is sufficient, and in infants, a fortnight.

FRACTURES OF THE SCAPULA.—1. **Fracture of the Body of the Scapula** is not very commonly met with ; and when it occurs, being always the result of considerable direct violence, it is usually associated with serious injury to the subjacent ribs and trunk. The thick layer of muscles overlying this bone not only protects it, but limits displacement, and renders the detection of its fracture difficult. The fracture usually takes place across the bone, immediately below the spine ; but occasionally it may be split longitudinally or starred.

The **Treatment** consists in placing the arm in a sling, the application of a body-bandage, and support of the part with a pad. But all Surgeons who have seen this accident are agreed as to the extreme difficulty of obtaining union without considerable deformity ; which, however, is of less moment here than in most other situations.

Fractures in the Vicinity of the Shoulder-Joint are of common

occurrence, and may happen either in the bony points of the scapula that overhang this articulation, or else in the upper end of the humerus. Not unfrequently there is double fracture in the neighbourhood of this articulation; thus the acromion may be broken, as well as the neck of the humerus. These complications, as well as, in many cases, the amount of contusion, and the rapid swelling that takes place, necessarily render the diagnosis somewhat difficult.

2. The **Acromion,** forming as it does the very tip of the shoulder, is more frequently broken than any other part of the scapula. But, in spite of its exposed situation, fracture of this process through its base is not very common; at least I have seen but few cases of it, and there is good reason to believe that many of the cases of supposed fracture in this situation are in reality cases of delayed ossification of the line of junction between the base and the epiphysis. Notwithstanding this source of fallacy, there can be no doubt, as is proved by numerous preparations, that this fracture does occur.

The **Signs** of this fracture are obvious. When the acromion is broken off near its root, the arm hangs as a dead weight by the side, and the patient, feeling as if his arm were dropping off, supports it with the other hand. There is flattening of the shoulder, which is most marked when the patient is looked at from behind; and the head of the humerus can be felt somewhat lower in the axilla than natural. On running the finger along the spine of the scapula, a sudden inequality in the line of the bone can be detected; and, on raising the elbow and rotating the arm, crepitus can be felt, the rounded outline of the shoulder being restored.

When the tip only of the acromion is broken off, the nature of the injury may be suspected if the patient be unable to raise his arm to a level with his head, so as to touch the crown, owing to some of the fibres of the deltoid having lost their points of attachment; and it may be determined by the existence in a minor degree of some of the preceding signs, which prevent the accident from being confounded with paralysis of the deltoid from contusion; and especially by the tip being felt to be detached. But as has already been stated, this may be a congenital defect, to which perhaps attention has been directed only when the shoulder has been bruised or otherwise injured.

The **Treatment** consists principally in raising the elbow, so as to take off the weight of the limb, and to push up the acromion by the head of the humerus. If the extremity only be broken off in front of the acromio-clavicular articulation, a pad may be placed between the elbow and the side, in order to direct the arm somewhat upwards and inwards, and the limb must be fixed in this position by a bandage and sling. Should the fracture have taken place at or behind the line of the clavicular articulation, the treatment must be the same as that for fractured clavicle.

When the base of this process is broken across, there is not much separation between the fragments, and union usually takes place by bone. When the apex is detached, fibroid or ligamentous union generally occurs, the fragments being widely separated.

3. The **Coracoid Process** is but seldom broken, there not being more than ten or twelve unequivocal cases of this accident recorded. It cannot happen, except by very direct violence. There is in the Museum of University College a recent preparation showing a fracture of the base of this process, implicating and extending through the glenoid cavity, and complicated with fracture across

the base of the acromion; and an old specimen, from a subject in the dissecting-room, showing a fracture through the middle of the process united by a fibrous band three-quarters of an inch in length. The attachment of such powerful muscles as the pectoralis minor, biceps, and coraco-brachialis, displaces the fragment considerably, and would do so still more, were it not that it is kept in position by the ligaments to which it gives insertion, and whose fibres are expanded over it.

The only **Treatment** that can be adopted is to put the arm in a sling and fix it to the side.

4. **Fracture of the Neck of the Scapula** immediately behind the glenoid cavity is a rare injury. Its existence has been doubted: A. Cooper and South have stated that cases so described are, in reality, instances of fracture of the upper end of the humerus. There is, according to South, no preparation in any museum in London illustrating fracture of the neck of the scapula. A case, however, recorded by Spence in the *Edinburgh Medical Journal* for 1863, puts the occasional occurrence of the injury beyond doubt. A man was brought into the Edinburgh Infirmary, who had fallen on his shoulder while intoxicated. There was falling of the limb towards the axilla, with projection of the acromion and flattening of the deltoid; and crepitus was felt. The contour of the shoulder was restored by drawing the arm from the side and raising the limb. The man died some days afterwards from meningitis, the result of an injury to the forehead which he had received during the fall. On examining the shoulder, "the fracture was found to pass obliquely from below, upwards and forwards, commencing about half-an-inch behind the origin of the long head of the triceps, and separating the neck and four-fifths of the lower part of the glenoid cavity from the scapula. The long head of the biceps and the whole of the glenoid ligament had also been torn from the upper fragment of the glenoid cavity, and carried along with the displaced portion."

In fracture through the neck of the scapula, the coracoid process would necessarily follow, the glenoid cavity being detached along with it. Mobility of the coracoid would, therefore, be a valuable sign in the diagnosis of this rare fracture.

The **Treatment** of such an injury, if it were diagnosed, would consist in keeping the whole arm well raised and fixed to the chest, with a pad in the axilla.

FRACTURES OF THE HUMERUS.—In studying the fractures of the humerus, we must divide that bone into three parts,—the Upper Articular End, the Shaft, and the Lower Articular End.

1. **Fractures of the Upper Articular End of the Humerus** not unfrequently occur, constituting an important class of injuries which have been carefully studied by Sir A. Cooper, and more recently by R. W. Smith, whose work on *Fractures* deserves the attentive perusal of every practitioner.

Five kinds of fracture of the humerus are met with in the immediate vicinity of the shoulder-joint. Two of these are *Intracapsular*, viz., Simple Fracture of the Anatomical Neck, and Impacted Fracture of this portion of the bone. The remaining three are *Extracapsular*, viz., Fractures of the Surgical Neck—Simple and Impacted; and Separation of the Great Tuberosity.

Intracapsular Fracture of the Neck of the Humerus.—When the fracture occurs at the *anatomical neck*, the head of the bone is detached from

the shaft, a little above or at the line of insertion of the capsule. This fracture is occasioned by severe falls or blows on the shoulder. It cannot result from indirect violence. A fall on the hand or elbow may dislocate the humerus or fracture its shaft, but it cannot break its upper articular end.

The signs of this injury are by no means very distinct, though much light has been thrown upon them by the labours of R. W. Smith. There is loss of motion in the shoulder, with some swelling and considerable pain, together with some deformity; an irregularity, produced by the upper end of the lower fragment, can be felt towards the inner side of the joint; crepitus is easily produced; and there is, on measurement from the acromion to the olecranon, shortening to the extent of about one-third of an inch.

When this fracture is *impacted*, the upper fragment penetrates the lower one. In consequence of this, the axis of the humerus is directed somewhat inwards towards the coracoid process; here also some irregular osseous swelling may be detected. The head of the bone can be felt in the glenoid cavity, but is not in the axis of the limb, the elbow projecting slightly from the side, there being at the same time a hollow some little distance under the acromion. There is consequently more deformity about the joint in the impacted than in the simple intracapsular fracture, with the same impairment of motion, but crepitus is wanting, or a slight grating may be felt, on firmly grasping the shoulder and rotating the elbow.

In fracture of the anatomical neck of the humerus, the portion of bone broken off may be completely loose, like a foreign body in the joint. Under these circumstances, theoretically it might necrose and give rise to destruction of the articulation, but I can find no recorded case of such an accident. It is probable in most cases, as R. W. Smith supposes, that its vitality is preserved in consequence of some partial union being kept up between it and the rest of the bone by untorn shreds of capsule, and in other cases it may be due to impaction. But supposing it were free, there is no reason why it should necessarily cause suppuration, any more than a loose piece of cartilage chipped off the femur in the knee. If perfect rest were maintained, it is possible that the loose fragment might form new adhesions to the shaft. In any case, the repair necessarily proceeds from the lower fragment.

Treatment.—As there is often much swelling from contusion in these cases, evaporating lotions should be had recourse to for a few days. A pad may then be placed in the axilla, and a leather- or gutta-percha-cap fitted to the shoulder and upper arm, the limb having previously been bandaged. The hand must be supported in a sling, and the elbow fixed to the side. In examining and reducing these intracapsular fractures, no violence should be employed, lest any impaction of the fragments be disturbed, or portions of untorn capsule, of much importance for the ultimate osseous repair of the injury, be broken through.

Extracapsular Fracture of the Neck of the Humerus.—In this injury, the bone is broken through the *surgical neck*, or that portion which is below the tuberosities, but above the insertions of the pectoralis major, latissimus dorsi, teres major, and deltoid muscles. This accident is most frequent in adults, but it may occur in children as well, the separation then taking place through the line of junction between the epiphysis and the shaft of the bone. In this fracture there is a double displacement; the upper fragment is rotated outwards by the infra-spinatus and teres minor, and abducted by the supra-

spinatus; whilst the shaft is drawn inwards by the pectoralis major, latissimus dorsi, and teres major, and upwards and forwards into the axilla, and towards the coracoid process, by the biceps, coraco-brachialis, triceps, and deltoid.

The **signs** of this fracture are sufficiently obvious. The glenoid cavity is filled by the head of the bone, which can be felt in it. Below this there is a depression; crepitus is easily produced if extension be made to bring the rough surfaces in contact, and there are great mobility of the lower fragment, and shortening of the limb to the extent of from three-quarters to one inch; but the most remarkable sign is the prominence formed by the upper end of the shaft of the humerus, which projects under the integuments, and can readily be felt under the coracoid process, when the elbow is pushed upwards and rotated. The axis of the bone also is directed obliquely upwards and inwards towards this point. In consequence of the irritation of the nerves of the axillary plexus by this fragment, which is often very sharp and angular, a good deal of pain is complained of in the arm and fingers. This sign, however, is not met with in children, when the epiphysis is separated from the shaft, owing to the greater smoothness of the fractured surfaces. There is often very great extravasation of blood in this fracture, owing to laceration of branches of the circumflex arteries.

Impacted Extracapsular Fracture of the Neck of the Humerus has been especially treated of by R. W. Smith in his excellent work on *Fractures*. In this injury, the superior fragment being penetrated by the inferior one, the continuity of the bone and its firmness are in a great measure preserved; hence, the usual signs of fracture, such as mobility, displacement, and crepitus, are not readily obtainable, and indeed the signs of this injury are chiefly negative. Thus, there are impairment of motion, slight deformity about the joint and upper part of the arm, and occasionally crepitus is obtainable with difficulty, and by firmly grasping the head of the bone whilst the elbow is being rotated. There is, as a rule, slight shortening, amounting to less than half an inch.

Fig. 203.—Apparatus for Fracture of the Neck of the Humerus.

In *children*, separation of the epiphysis from the shaft is common, and especial care must be taken not to confound this accident with a dislocation. The diagnosis is always easy. In children under puberty dislocation of the head of the humerus scarcely ever occurs. In the fracture, the head can be felt in the glenoid cavity; but above all the broad end of the shaft, for the fracture in them is always transverse, may be felt drawn up under the coracoid process, and cannot be mistaken.

The **Treatment** in these cases should be carried out in accordance with the following principles and details: 1. To bandage the hand and arm so as to prevent congestion and œdema of the limb; 2. To place a pad in the axilla to act as a fulcrum; 3. To bandage the elbow closely to the side so as to overcome the displacement inwards of the upper end of the shaft, which will be thrown outwards by the axillary pad; 4. To carry the elbow (whilst it is being bandaged to the side) forwards across the chest, in advance of

the lateral median line, in order to counteract the forward displacement of the upper end of the shaft, and thus to throw it backwards towards the head of the humerus; 5. To apply a sling so as merely to support the hand and wrist, allowing the elbow to hang unsupported, and thus letting the weight of the arm counteract the displacement upwards (Fig. 203). By these means the triple displacement of the upper end of the lower portion of the shaft inwards, forwards, and upwards will be counteracted. The whole is then to be steadied by means of a leather- or gutta-percha-cap, carefully moulded and fitted to the shoulder and arm. As the bruising and extravasation are often very considerable in these cases, it is as well to apply evaporating lotions in the first instance.

In the management of some of these fractures, I have found a very convenient apparatus in a leather splint about two feet long by six inches broad, bent upon itself in the middle, so that one half of it may be applied lengthwise to the chest, and the other half to the inside of the injured arm; the angle formed by the bend, which should be somewhat obtuse, being well pressed up into the axilla. In this way the limb is steadied, and the tendency to displacement inwards of the lower fragment is corrected.

In some cases, fracture of the neck of the humerus is followed by atrophy of the bone, though good union has taken place.

Compound Fracture of the Surgical Neck of the Humerus is not of common occurrence. I have had a case under my care in which this accident happened to a lad from a fall out of a window. The fracture was transverse, and the upper extremity of the lower fragment was driven upwards, and protruded through the deltoid, to the extent of an inch and a half. It was reduced with difficulty: as great irritation was set up around the seat of injury, and as there was a tendency to recurrent protrusion of the upper extremity of the lower fragment, this was turned out by enlarging the wound, and about an inch and a half of it sawn off. Union took place between the fragments, and recovery was effected with a very useful arm.

Separation of the Great Tuberosity of the Humerus occurs occasionally from falls and blows upon the shoulder; but more commonly as the result of the violent action of the three external rotator muscles which are inserted into it. In this injury there is a double displacement; the tubercle is carried upwards and outwards away from the head of the bone, and under and external to the acromion process; the head is drawn upwards and inwards by the muscles passing from the trunk to the arm, as well as by the flexors of the arm, in such a way that it lies upon the inner edge of the glenoid cavity under the coracoid process, and is indeed almost luxated. The consequence of this double displacement is a great increase in the breadth of the shoulder, which has nearly double its natural size; on examination, a rounded tumour—the head of the bone—movable on rotating the arm, can be felt under the coracoid process, whilst another osseous mass—the great tuberosity—may be felt at the outer and back part of the joint; between these a sulcus is perceptible, and crepitus may be felt by bringing the two portions of bone into apposition and rotating the arm. This accident, which is rare, has been most carefully described by Guthrie and Smith, to whom we are indebted for our knowledge of its pathology.

The **Treatment** consists in an attempt to bring the detached tuberosity into

contact with the head of the bone, and retain it there: this may be done either by mechanical means, or by relaxation of the muscles. The treatment by mechanical means consists in placing a pad in the axilla, and bringing the elbow to the side so as to throw out the head of the bone, at the same time that, by means of a compress, the tuberosity is pressed into proper position, the arm being supported in a sling. The treatment by relaxation of the muscles consists in elevating and extending the arm from the trunk; in carrying this out, it is necessary that the patient be confined to bed, the arm being supported on a pillow.

The **Period of Union in a Fracture of the Neck of the Humerus** is about five weeks, at the end of which time the apparatus may be removed, but the patient will not recover the use of the arm fully till about the end of the seventh or eighth week.

Compound and Comminuted Fractures of the Head of the Humerus can occur only as a consequence of gun-shot-injury. In these cases there may be splintering also of the acromion or coracoid processes, of the neck of the scapula or glenoid cavity, and possibly injury to the axillary vessels and plexus of nerves.

The **Treatment** must depend upon the extent of the complications. If the injury be confined chiefly to the head of the humerus, with little damage to the soft parts, and none to the main vessels or nerves, excision should be practised, any splinters in connection with the scapular processes being removed at the same time. Should, however, the soft parts be extensively disorganized, and especially the great vessels and nerves torn, amputation is the sole resource.

2. **Fractures of the Shaft of the Humerus** are usually somewhat oblique from above, downwards and outwards. They may occur from any kind of external violence, but are more frequently the result of muscular action than those of any other long bone. The nature of the accident can be at once detected by the great mobility of the fragments, the ready production of crepitus, and the other ordinary signs of fracture. The direction of the displacement depends upon the seat of the fracture. If the bone be broken above the insertion of the deltoid, and below those of the pectoralis major, latissimus dorsi, and teres major muscles, the lower fragment will lie to the outer side of the upper, and will be drawn upwards while the lower end of the upper fragment will be drawn inwards. If the fracture be below the insertion of the deltoid, the upper fragment will be abducted by that muscle, and the lower will be to its inner side.

In proportion to the frequency of fracture of the shaft of the humerus ununited fracture occurs more commonly in this than in any other bone.

The **Treatment** is of the simplest character. A rectangular internal splint should be applied, reaching from the axilla to the wrist, and two or three short pasteboard or wooden splints to the three other sides of the limb, and the elbow and fore-arm may be supported in a sling. In applying the splint to the inner side of the arm care must be taken not to press upon the axillary vein, lest œdema of the limb occur, and a small circular hollow pad should be arranged so as to protect the inner condyle. In many cases an angular outer splint carried from the acromion to the hand is the best apparatus that can be employed. In these cases the elbow must be well supported, contrary to what is done in fractures of the surgical neck. For if in fractures of the

shaft, the elbow and whole of the fore-arm be not well supported in a sling or trough, their weight may drag down the lower fragment, cause elongation of the limb, and thus lead to separation between and disunion of the fragments.

The **Period of Union in Fractures of the Humerus** is about five weeks. According to the statistics of Leisrink, consolidation should be complete by the thirty-third day, and the patient should have regained the use of his arm at the end of the seventh week.

3. **Fractures in the Vicinity of the Elbow-joint** may occur through any of the osseous prominences in this situation. They are very commonly complicated with dislocation, with severe contusion and injury of the joint, or perhaps with comminution of the bones, and considerable laceration of the soft parts covering them. In most cases swelling speedily comes on, tending to obscure materially the nature of the injury. They may be classified as—Separation of the Lower Epiphysis of the Humerus ; Transverse Fracture of the Lower End of the Bone ; Fracture of either Condyle ; and to these may be added Fracture of the Olecranon.

In examining a supposed fracture about the elbow-joint, the Surgeon should stand in front of the patient, who must have both elbows exposed, and should carefully compare the injured with the sound side. To do this he should flex the patient's elbows to a right angle and let the upper part of each fore-arm lie on the palm of his hand, while he places his thumb upon the outer condyle, his index-finger on the olecranon, and his middle finger on the inner condyle. He thus readily judges whether these three points of bone are in their normal relation to each other. He should then pass the thumb or finger of each hand simultaneously over the bony points on the two sides and carefully contrast them. An assistant may, if necessary, pronate and supinate the hands.

Separation of the Lower Epiphysis of the Humerus before its ossification with the shaft is complete, is a frequent accident in children ; the fragment being carried backwards, with the bones of the fore-arm connected with it, so as to cause considerable displacement posteriorly. In this accident the trochlea, the capitellum, and the condyles, are broken off from the shaft, which remains *in situ*. It is the detached articular end of the bone that is carried backwards with the fore-arm by the action of the triceps muscle. The detached fragment may readily be replaced ; but as soon as it is left to itself, it again slips out of its position. As this happens without bony crepitus, owing to the fracture being between cartilaginous surfaces, although there may be a peculiar soft crackling, the injury is apt to be mistaken for dislocation of the fore-arm backwards.

Transverse Fracture of the Lower End of the Humerus, just above the condyles, occurs occasionally in adults. The displacement backwards of the fore-arm and lower fragment, the pain, and crepitus, indicate the nature of the accident.

Fracture of either Condyle of the Humerus may arise from blows and falls on the elbow. There is considerable pain about the seat of the injury, but usually not much displacement ; unless, as in Fig. 204, there be a transverse fracture of both condyles, constituting what may be termed the T-shaped fracture of the lower epiphysis of the humerus. Crepitus, however, may readily be felt by rotating the radius, if it be the external condyle that is injured ; or

by flexing and pronating the fore-arm, if it be the internal condyle that has been detached.

The **Treatment** of all these injuries must be conducted on very similar principles. The swelling and inflammatory action, which rapidly supervene, usually require local antiphlogistic treatment, and the application of cold lotions, or of irrigation ; the arm being flexed, and supported in an easy position on a proper splint. After the subsidence of the swelling, the fractured bone, whatever be the precise nature of the injury, is best maintained in position by being put in an angular splint applied to the inner side of the limb (Fig. 205) ; the fore-arm being kept in the mid-state between pronation and supination, and well supported in a sling.

It is in these particular fractures that passive motion should be had recourse to early, a tendency to rigidity of the joint being otherwise often left. The

Fig. 204.—T-shaped Fracture of Lower Epiphysis of Humerus.

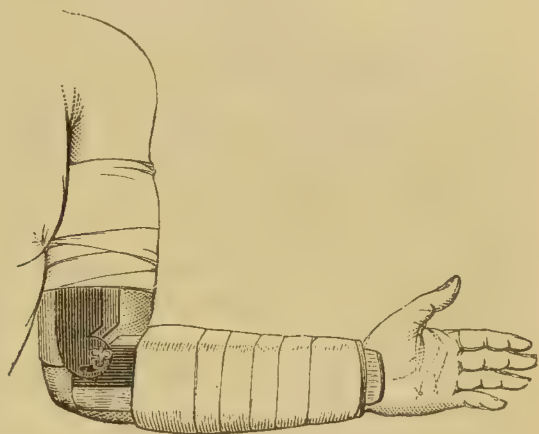


Fig. 205.—Angular Splint applied to inside of Arm.

motion should be begun in adults at the expiration of a month or five weeks ; in children, at the end of three weeks after the occurrence of the accident. Union usually takes place readily. I have, however, seen one instance of an ununited fracture of the external condyle of the humerus in a boy about ten years old.

Period of Union.—These fractures unite quickly, bony union being complete in four weeks, but it is seldom before the end of the sixth week that the patient recovers the use of his arm.

Injury of Nerves in Fracture of the Humerus.—In simple fracture of the shaft of the humerus, it may happen that the trunk of the musculo-spiral nerve, where it winds round the bone in a flat groove, may be so seriously damaged, either by the fracture itself or by becoming involved in the subsequent formation of callus, as to occasion its paralysis. So also when the fracture is lower down, and the external condyle is broken off, the posterior interosseous branch of that nerve may be injured. When the main trunk is paralysed, supination is imperfect, and extension of the hand and fingers is entirely lost ; the fore-arm becomes pronated, and the hand and fingers passively flaccid, so that a form of *wrist-drop* ensues ; all the muscles supplied by the musculo-spiral nerve becoming paralysed. Some degree of supination, however, can be done by the action of the biceps. Although the extensors of the wrist and fingers have become paralysed, yet, when

the fingers are flexed into the palm (Fig. 206, *a*), they can be extended rapidly, and with some degree of force, at the first inter-phalangeal articulations, as far as is represented in Fig. 206, *b*. This limited movement of extension is due to the action of the interossei and lumbricales muscles, which, being supplied by the ulnar and median nerves, do not participate in the paralysis that affects all the long extensors of the fingers. M. Duchenne de Boulogne pointed out that the interossei muscles extend the second and third phalanges and flex the first phalanx, flexion of the two distal phalanges being accomplished entirely by the long flexors.

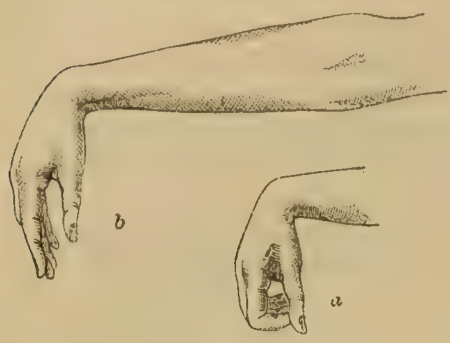


Fig. 206.—Paralysis of Hand (Wrist-Drop) after Fracture of Humerus.

When the posterior interosseous nerve only is paralysed, the loss of supination and extension is necessarily not so complete as when the whole trunk is affected; these movements being still practicable to a limited extent, through the medium of the long supinator and the long extensor of the wrist, which are supplied by the radial branch. If the paralysis of the extensors and supinators be allowed to continue for some time, the fore-arm and arm become drawn into a state of permanent flexion and pronation, by secondary, or so-called pathological, shortening of the muscles that act in those directions (Fig. 207).

The treatment of this complication of simple fracture of the humerus must be


Fig. 207.—Permanent Flexure from Paralysis after fracture of Humerus.

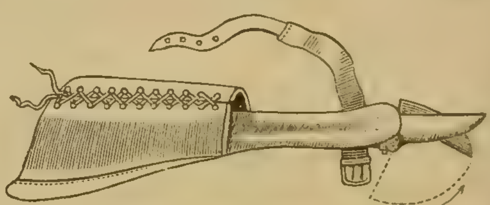


Fig. 208.—Apparatus for Wrist-Drop after Fracture of the Humerus.

conducted on the principles laid down in the Chapter on Injuries of Nerves. The patient should be encouraged to use the hand as much as possible as soon as the state of the fracture will allow of it, and a splint may be applied at night to prevent the occurrence of deformity. In order to overcome the flexion of the hand and fingers, due to the unopposed action of the long flexors, the splint (Fig. 208) may be employed with advantage, the hand-piece admitting of upward movement, so as to raise the hand and extend the fingers forcibly.

In a case in which the symptoms denoted pressure on the musculo-spiral nerve by one of the fragments or by the callus, Ollier of Lyons cut down on the bone, removed a portion of the callus by chisel and mallet, so as to expose the nerve, and excised also a portion of bone (apparently of the lower fragment), which was strangulating the nerve. Gradual improvement took place: and, at the end of six and a half months, the patient had regained considerable power of extension of the wrist. Whitson of Glasgow performed a similar operation, and in his case the improvement was more rapid.

Compound and Comminuted Fractures of the Elbow-Joint are necessarily serious accidents. They are commonly occasioned by falls on the point of the olecranon, which is the process of bone most frequently and extensively fractured. In some cases the olecranon escapes injury, whilst the lower epiphysis of the humerus is splintered into many pieces ; and more commonly, perhaps, both bones, ulna as well as humerus, are injured. As the integuments over the point of the elbow are thick and hard, very extensive comminution of the bones may occur with very little apparent injury of the soft parts. When these fractures are the result of gun-shot-injury, the soft parts may be extensively torn, and the bones greatly shattered. In the cases that occur in civil practice, I have seldom seen much laceration of the soft parts.

The **Treatment** of these important accidents must necessarily depend on the amount of injury done both to bones and soft parts. If the articulation be simply opened with little laceration of the surrounding soft parts, and no comminution of the fractured bone, the limb may very commonly be saved. If the bones be much shattered, the soft parts not being seriously implicated, removal of the splinters, or resection of the injured joint, will enable the Surgeon to save the rest of the limb ; but if the soft parts be extensively contused and torn, as well as the bones comminuted, amputation of the arm may be required. If an attempt be made to save the joint without operation, great attention must be paid to drainage, rest, and prevention of decomposition. If the cavity become filled with septic matter, not only will there be severe septic fever, but abscesses will form in front of and around the joint, the splintered fragments will necrose, and excision, or possibly amputation of the limb, will be necessary in a few weeks. These cases, however, as a rule, do very well when treated antiseptically, either by carbolic gauze or iodoform-wool.

Perfect rest may in these cases be obtained by the plan recommended by H. O. Thomas of slinging the hand up over the upper part of the chest by a bandage secured by a clove hitch to the wrist, and tied round the neck.

If the comminution is such as to render removal of the splintered fragments necessary, or if it be evident that recovery can take place only with a stiff elbow-joint, resection should be performed. In these cases the question may arise whether a partial or complete removal of the articulation should be practised. This will depend much upon circumstances. If the comminution is such as to require the removal of a considerable length of the humerus, it is better, if possible, to leave the bones of the fore-arm untouched, otherwise a flail-like arm is certain to result. If but little length of bone has to be removed, there is some danger of a stiff elbow resulting unless the whole cartilage-covered surfaces of the bones are removed. In cases in which a secondary excision becomes necessary after an attempt to save the joint has failed, it is better to follow the ordinary rule of removing all the articular surfaces even if but one is injured, as in these cases the cartilages have often necrosed from the irritation of the septic discharges and would seriously delay the cure. When primary resection is determined on, the sooner the operation is done the better ; when a secondary operation is performed, after septic inflammation has followed the accident, the Surgeon must wait till the septic fever begins to subside, and suppuration is fully established, and then he should do it with as little delay as possible lest hectic or pyæmia supervene. The operation as performed differs in no material respect from the same operation for disease of the articulation, which will be described in Chapter XLIX. In primary

excision great care must be taken to save the periosteum as much as possible, otherwise a flail-like joint may result. In secondary operations, as the periosteum is loosened by the inflammation, it usually is saved without difficulty.

FRACTURES OF THE FORE-ARM.—1. The only fracture of the bones of the fore-arm that commonly occurs *in the vicinity of the elbow-joint*, is that of the **Olecranon** ; this happens almost invariably from falls upon the elbow, and hence is usually accompanied by very considerable bruising and swelling of the parts. It may possibly, though very rarely, occur from muscular action. The displacement is usually considerable, the detached fragment being drawn upwards by the triceps muscle. Occasionally, however, when the ligamentous expansion of the tendon of this muscle is not torn through, there is but little separation of the fragments. In the majority of cases, as the injury takes place from direct violence, there is much swelling about the joint ; and not unfrequently the fracture is comminuted or compound.

Fig. 209.—Fracture of Olecranon.

The **Treatment** is best conducted by moderately straightening the arm, and maintaining it in that position by means of a well-padded light wooden splint laid along its fore part. But, although the arm should be kept nearly straight, it should not be quite extended. The best and most easy position in which to put it up is that into which the arm naturally falls when hanging by the side ; in this there will be seen to be slight flexion at the elbow (Fig. 210). If the fore-arm be too rigidly extended on the arm, it may be carried backwards beyond the straight line, owing to loss of the resistance of the olecranon against the fossa at the back of the humerus.

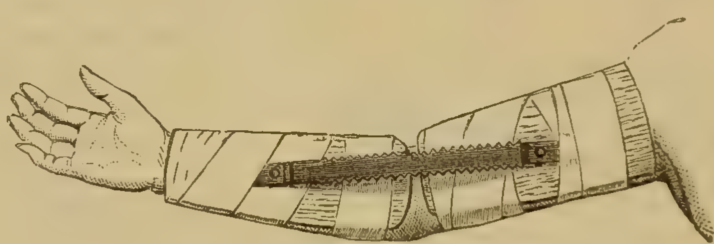


Fig. 210.—Apparatus for Fractured Olecranon.

As a rule, union takes place by firm fibrous tissue, but bony union has sometimes been obtained. Should the union be so loose as to render the arm useless, it has been recommended to cut down on the seat of fracture, freshen the bony surfaces, and apply a wire-suture as in the treatment of ununited fractures elsewhere. In order to do this without the risk of suppuration, the strictest antiseptic precautions must be observed. The operation has been successfully performed by Lister and Sir William MacCormac ; but the cases in which such an operation could be required are very rare.

Period of Union.—A simple fracture of the olecranon is usually united with sufficient firmness to allow of the splint being abandoned in from four to five weeks.

In **Compound Fracture of the Olecranon**, the joint must be syringed out with an antiseptic solution, and treated by some form of antiseptic dressing. König recommends that, whenever possible, the fragment should be fixed to the ulna by wire sutures, care being taken to provide drainage from the joint on each side of it. In cases in which suppuration has taken place, and when there is a probability of ankylosis, the semi-flexed would be preferable to the straight position. If destruction of the joint follow, excision may be necessary.

Fracture of the Coronoid Process of the Ulna has been supposed by many Surgeons to be a common complication, and, indeed, a cause of dislocation of the ulna backwards. There is every reason, however, to believe that this is an error, and that, in point of fact, it is one of the rarest accidents in surgery—at least, we must come to this conclusion, if we are to judge by the small number of recorded cases or of preserved specimens of this injury. Hamilton states that there are but eight cases on record in which the symptoms led to a belief that this accident had occurred; that in none of these cases were the symptoms unequivocal; and that in not one case did dissection afford an opportunity of positively demonstrating this fracture. There are but four preparations in existence, according to Hamilton, illustrative of this injury, and all these, he says, are doubtful. In the cases in which this accident has been supposed to have occurred, the injury has arisen from falls on the palm of the hand, by which the ulna has been driven backwards, and the coronoid process, striking against the lower end of the humerus, splintered off. In a case related by Liston, the injury is said to have been produced by muscular action in a boy, who, hanging for a length of time by his hands from a high wall, fell to the ground, and was supposed to have met with this fracture. Whether the fracture actually occurred is doubtful; and, if it did, it is still more doubtful whether it was occasioned by the contraction of the brachialis anticus muscle, or by the violence of the fall.

In the present uncertain state of our knowledge, I forbear to speak of the supposed symptoms of this accident. If it were suspected, the proper treatment would consist in placing the limb in angular splints.

2. **Fractures about the Middle of the Fore-arm** are of very common occurrence, both bones being usually broken, with much shortening, angular displacement, and crepitus. Occasionally one bone only is fractured, from the application of direct violence. When this is the case, more attention will be required in establishing the precise nature of the injury.

The **Treatment** is simple; a plain wooden splint somewhat broader than the arm should be placed on each side of it, and a narrow pad laid along the interosseous space, in order that the patency of this may be preserved; no bandage should be placed under the splint, nor must the bandages that are over the splints touch the sides of the arm. The fore-arm must be placed mid-way between pronation and supination, as this gives the greatest natural interval between the two bones. When the arm is hanging down, the thumb should be upwards; a fractured fore-arm is however usually put up while the patient is seated with his arm raised to the level of his head, and the elbow bent at a right angle, the Surgeon standing in front of him. The student is apt to forget that, for the bones to be mid-way between pronation and supination in this position, the thumb must be pointing towards the patient's face.

If the bones be put up in an improper position, or squeezed together, a mass

of callus may be thrown out across the interosseous space uniting them together. Pronation and supination of the hand will then be lost, and the utility of the limb greatly impaired (Fig. 211).

Fig. 211. — Obliteration of the interosseous space in a fracture of the fore-arm.

Period of Union.—The average time of union in the fore-arm is five weeks.

Compound Fractures of the Fore-arm seldom give much trouble or require amputation, but they very commonly lead to obliteration of the interosseous space, and thus impair the utility of the limb, by preventing pronation and supination.

3. **Fractures of the Lower Extremity of the Radius**, near the wrist, are very frequent, especially in women after the age of 45. Their importance, not only from a diagnostic point of view, but also in reference to treatment, has caused them to be carefully studied; and their nature and pathology have been specially investigated by Colles, Goyrand, Voillermier, Nélaton, R. W. Smith, and Gordon.

The lower end of the radius is liable to several different kinds of fracture. The more common of these is that which is generally called "**Colles's Fracture**," from the eminent Surgeon who first fully described it. In this fracture the carpal end of the radius is broken across, usually by a fall on the palm of the hand, the lower fragment being displaced backwards. Dr. Gordon, who has bestowed great attention on the mechanism and treatment of this fracture, states that, in twenty-seven old specimens examined by him, the line of fracture posteriorly varied from $\frac{3}{8}$ to $1\frac{3}{4}$ inch, and anteriorly from $\frac{3}{8}$ of an inch to two inches above the carpal border of the radius, being in ten of the cases one inch and under, in ten more than one inch but not over $1\frac{3}{4}$ inch, in the others indefinable. The fracture is usually oblique from before backwards. Besides Colles's, other fractures are met with in this situation. They are of three kinds; 1, Simple Transverse; 2, with Comminution of the Lower Fragment; and 3, with firm Impaction of the Upper into the Lower Fragment.

The **Signs** of fracture of the lower end of the radius vary greatly, according to their nature. When *simple*, there is usually no very great displacement; but there will be noticed some tumefaction about the wrist, a swelling at its dorsal aspect, loss of the movement of the radius, and crepitus on rotating the bone whilst the hand is drawn down. When the fracture is *comminuted*, and still more so when *impacted*, the signs are very marked and characteristic; so much so, that they may always be looked upon as diagnostic of these forms of this accident. The deformity thus occasioned gives rise to a remarkable undular distortion of the wrist. On looking sideways at the hand and fore-arm which are held midway between supination and pronation, it will be seen that there is a considerable dorsal prominence apparently situated just above the back of the carpus (Fig. 213); immediately underneath this, on the palmar aspect of the wrist, just opposite the annular ligament, there is a remarkable hollow or arch, confined to the radial side of the arm; a little above this—that is to say, on the lower part of the anterior aspect of the fore-arm—there is another rounded prominence, not nearly so large or distinct, however, as the

one on the dorsal aspect. The hand is abducted and rotated outwards, so that its axis is oblique to that of the fore-arm; the ulnar border being somewhat convex, and the styloid process of the ulna projecting sharply under the skin (Fig. 212). The radial side of the wrist is, on the contrary, somewhat concave, appearing to be shortened.

The pain at the seat of injury is very severe, and is greatly increased by

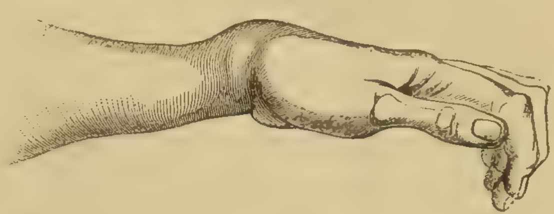


Fig. 213.—Fracture of Lower End of Radius: Side View.

Fig. 212.—Fracture of Lower End of Radius: Back View.

moving the hand, especially by making any attempt at supination. The hand is perfectly useless, the patient being unable to support it. All power of rotating the radius is lost, the patient moving the whole of the arm from the shoulder at once, and thus apparently, but not really, pronating and supinating it. Crepitus can readily be felt when the fracture is simple or comminuted; but when it is impacted, the most careful examination fails to elicit it.

The *Cause of the particular Deformity* that is observed, and indeed the general pathology of the injury, has been the subject of much discussion; in a great measure owing, I believe, to the rarity of the opportunities of dissecting recent fractures of this kind. Surgeons are, however, now agreed that the dorsal prominence is due to the lower fragment, carrying the carpus with it, being displaced backwards and upwards; whilst the palmar tumefaction is due to the projection forwards of the lower end of the upper fragment, which is thrown into a state of pronation. There is thus a double cause of displacement in operation. The displacement of the upper fragment is evidently due to the pronatores quadratus and radii teres; but to what is the displacement of the lower fragment due? Is it to the peculiar manner in which the two fragments are locked into one another? or is it due to muscular action? Some years ago I had an opportunity of dissecting and carefully examining the state of the limb in a woman who died from other causes in University College Hospital twelve days after meeting with this accident. On examining the left arm, which presented all the signs of this injury in a marked degree, and from which Fig. 212 was taken, a transverse fracture of the radius was found about an inch above its articular surface. The lower fragment was split into three portions, between which the upper fragment was so firmly impacted to the depth of more than half an inch, as to require some force in its removal. The three portions into which the lower fragment was split were of very unequal size; the two posterior ones being small, consisting merely of scales of bone; the third fragment, the largest, comprising the whole of the articular surface of the radius, which was tilted somewhat upwards and backwards, carrying the

hand with it. To this fragment were attached the supinator longus, and part of the pronator quadratus; the ligaments and capsule of the joint were uninjured.

This case presented the appearance usually met with in this kind of injury;

Fig. 214.—Fracture of Lower End of Radius; Displacement of Articular Surface.

Fig. 215.—Fracture of Lower End of Radius: Displacement of Lower Fragment.

the lower fragment being displaced in such a way that its articular surface looked slightly backwards, and somewhat outwards, so as to be twisted as it were upon its axis. The upper fragment was found in a state of pronation, and was driven into and firmly impacted in the lower one.

That the deformity in this case was the result of impaction, there could be

Fig. 216.—An old Colles' Fracture of the Radius. Showing the dorsal prominence made by the Lower Fragment and the Carpus, and the palmar projection caused by the anterior part of the lower end of the Upper Fragment.

no doubt; and that impaction is the cause of deformity in many cases, is proved by an examination of several specimens of consolidated fracture of the radius preserved in the different collections in London, and by the difficulty of accounting in any other way for the occasional impossibility of properly reducing these fractures. The great traction that is usually required to remove the deformity, and the absence of distinct crepitus until after forcible traction has been employed, indicate the existence of this impaction.

Mechanism.—The mode in which the accident occurs, and the position of the hand at the moment of its coming into contact with the ground, will, I think, materially influence the kind of fracture that occurs as well as the consequent

amount and character of the resulting deformity. When a person falls on his hands outstretched to save him, the limb is usually not completely pronated. It is half-way between complete pronation and the mid-state between pronation and supination. Complete pronation is a forcible muscular effort which is not carried to the full extent at the moment of danger. The hand is in fact three-quarters pronated—not wholly so. The effect of this position is, that the ulnar border is directed slightly downwards and first comes into contact with the ground, and the fracturing force is directed in a line that is somewhat towards the radial side, as well as backwards and upwards. Hence the hand is driven from the ulna towards the radius, causing the strongly marked projection of the styloid process of the ulna; and, the radius being broken across at its lower end, the fragment, carrying with it the carpus and hand, is driven backwards, upwards, and slightly outwards, causing the double deformity of a projection at the back of the fore-arm immediately above the carpus, and the concavity along the outer line of the radius.

But if, as sometimes happens, the hand be completely and forcibly pronated at the moment when it touches the ground, then the shock, which is received principally on the ball of the thumb and the radial side of the wrist, impinges in a direction obliquely from before backwards, and from without inwards, as well as from below upwards, and thus has a tendency, as soon as the bone is broken, to rotate the lower fragment on its own axis, and to tilt the articular surface somewhat upwards and outwards. As the upper fragment descends, its posterior surface of compact tissue is forced into the cancellous structure of the lower fragment until the two posterior portions of compact tissue come into contact; and thus the upper line of compact tissue is driven into the lower fragment, to an extent corresponding to the degree with which the fragment is rotated upwards and backwards. If the bone be brittle, or the force be continued after this amount of impaction has taken place, the lower fragment will be splintered. The prominence of the styloid process of the ulna in this case is the result of the shortening of the radial side of the wrist and hand, consequent upon the impaction.

Fig. 217.—A section of the bone from which Fig. 215 was taken. Showing the impaction of the compact tissue of the posterior aspect of the Upper Fragment into the cancellous tissue of the Lower.

When the fracture is simple, or when it is comminuted without impaction, I agree with R. W. Smith that the displacement of the lower fragment is the result of muscular action alone. This I have had an opportunity of observing in the following case. A man, 64 years of age, fell to the ground from a height of twenty-five feet. In his fall he broke the left radius just above the wrist, but also met with such serious injuries of the pelvis and abdomen, that he died in an hour after admission into the Hospital. On carefully dissecting the arm about twenty-four hours after death, I found that the radius was fractured transversely about half an inch above its lower articular end, and that the lower fragment was completely comminuted. The wrist, which presented all the signs of this fracture in a very marked, but not an extreme degree, could not be restored to its normal shape by any amount of traction that I could employ. On exposing the muscles of the limb, it was found that the

supinator longus was attached to the lower, and the pronator quadratus to the upper fragment; the latter muscle being slightly lacerated at its lower part. The upper fragment was strongly pronated. The chief cause of displacement, and the main obstacle to reduction, was found to exist in the two radial extensors of the wrist, the tendons of which were excessively tense; next to these, the special extensors of the thumb presented most tension, and then the supinator longus, which was far less tense than either of the other sets of muscles, but especially than the radial extensors, the tendons of which were strongly defined. On dividing these tendons, and on pressing the lower end of the upper fragment outwards, reduction was easily effected. Here the displacement was evidently due to two causes. The upper fragment was forcibly pronated by the action of its special pronators; and the hand, with the lower fragment attached, was drawn upwards and backwards by and in the direct line of the radial extensors of the wrist. There was no impaction nor interlocking of fragments, but perfect mobility, and hence muscular action was enabled to come into play.

In another case which I have since dissected, the muscles chiefly at fault

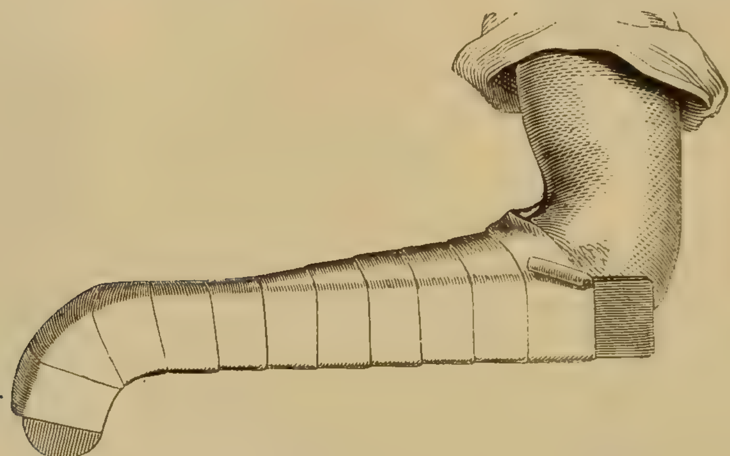


Fig. 218.—Old Pistol-Splint for Treatment of Fracture of the Lower End of the Radius.

were the radial extensors; next to these the extensors of the thumb; the supinator longus being but slightly if at all contracted.

Besides this injury, R. W. Smith has described a fracture of the lower end of the radius in consequence of falls upon the back of the hand, in which the inferior fragment is displaced forwards. In these cases the character of the deformity indicates the nature of the injury. It can readily be reduced, with a feeling of crepitation, by traction.

In another variety of fracture in this situation, the lower end of the radius and that of the ulna are broken off, resembling very closely dislocation of the wrist backwards. But the existence of grating, the ready reduction of the swelling, and the attachment of the styloid processes of the radius and of the ulna to the carpus, with which they move, will be sufficient to establish the diagnosis.

The **Treatment** of the ordinary fracture of the radius near the wrist may be conducted by the apparatus (Figs. 218, 219). This consists of a pistol-shaped wooden splint, which is placed along the outside of the arm, reaching from the elbow to the extremity of the fingers. Forcible extension and counter-

extension should be practised, with the view of disentangling the fragments, and removing the dorsal prominence. The splint should be carefully padded, the padding being made thicker opposite the lower fragment, and then, with the straight portion held vertically, the head of the splint should be fixed to the back of the hand. Gentle extension should then be made, and the hand bent to the ulnar side by raising the straight portion of the splint to the horizontal position, so as to make it lie against the back of the fore-arm, and held there, while another straight splint, extending from the elbow to the lower end of the upper fragment, is placed on the inner side of the fore-arm. Both splints should then be fixed by means of a roller, care being taken to have the inner splint well padded along the radial border, so as to counteract the tendency to pronation of this part of the bone. The arm must then be placed in a sling. The pistol-splint should be worn for a fortnight or three weeks. At the end of this time a gauntlet of gutta-percha, or other plastic material, may be moulded to the wrist and worn instead of the splint. All apparatus should be discontinued at the end of five weeks in the adult, a week or two earlier in children. When the fracture is impacted, little if any alteration in the deformity can be produced; when it is mobile, it may usually be brought into good position. The fracture unites in the course of a month or five weeks. After the first week it is well, especially in elderly people, to leave

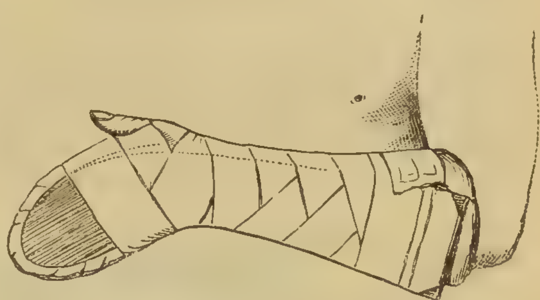


Fig. 219.—Pistol-Splint shaped to hand.

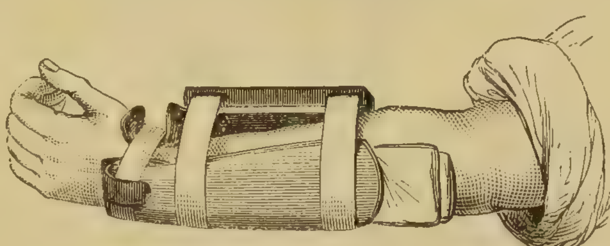


Fig. 220.—Gordon's Splint.

the fingers free, and to encourage movement of them, lest that painful stiffness result which is so common a sequela of the accident. Passive motion of the wrist-joint may, however, often be commenced, with great advantage to the patient, before the union of the fracture, more particularly when it is impacted. If the hand and fingers be kept fixed on the splint until the fracture is fully united, very troublesome and painful stiffness will result. It is frequently fully three months before this stiffness of the hand and wrist is so far diminished, even by the use of friction and douches, as to enable the patient to use the fingers, the stiffness of the wrist being often due to the extension of a fissure into the joint. It sometimes happens that in both arms the radius is broken at the same time in this situation, constituting a somewhat serious condition, inasmuch as the patient is not able to feed or assist himself in any way during the treatment.

The accompanying Figs. 220 and 221, represent two forms of splints that have justly many advocates, viz., Gordon's and Nélaton's.

Another form of splint which will be found most efficient in overcoming the deformity and comfortable to the patient, is that invented by Carr a few years ago (Fig. 222). It consists of a narrow splint slightly hollowed out to fit the radius, obliquely across the end of which is a cylinder of wood about four inches long by one in diameter. This is padded with cotton-wool and applied to the fore-arm in such a way that the cylinder corresponds to the metacarpo-phalangeal articulations. A short splint, about two inches wide, is then placed on the back of the arm, and both are secured by a few turns of bandage. The fingers are now bent down so as to make them firmly grasp the cylinder of wood. A few turns of bandage may at first be applied to keep the fingers in position, but after the first week the bandage must not extend beyond the carpo-metacarpal articulation, the fingers being left perfectly free to move. By the use of this apparatus the tendency to stiffness of the fingers is greatly diminished.

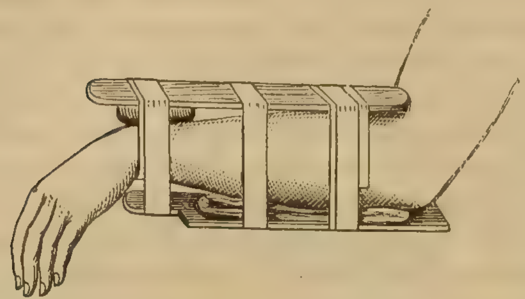


Fig. 221.—Nélaton's Apparatus.

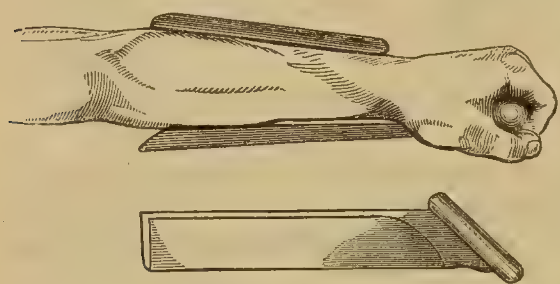


Fig. 222.—Carr's Splint.

Fractures of the Metacarpus and Fingers are of so simple a character as scarcely to call for detailed remarks. There is only one accident to a metacarpal bone that can lead to any difficulty in diagnosis. It is the case in which the neck of the bone is broken transversely, so that the head is carried forwards with the finger, and thus simulates closely a dislocation of the fingers towards the palmar surface. A comparison of the line of the bent knuckles, with crepitus on rotation, will pretty easily determine the real injury. In the *Treatment*, rest of the part upon a leather, gutta-percha, or pasteboard splint is all that is requisite. In compound fracture of these bones, every effort should be made to save the part; if removal become necessary, it should be as limited in extent as possible (p. 95).

Period of Union.—A fracture of one of the bones of the hand is firmly united by the end of the third week, when splints will no longer be required.

FRACTURES OF THE PELVIS AND THE LOWER EXTREMITY.

Fractures of the Pelvis.—The pelvic bones can be broken only by great and direct violence. The complete circle which they form, their solidity, and the strength of their synchondroses, enable them to resist all indirect causes of fracture. In civil life these bones are usually broken by crushes of the body, as between a cart and a wall, by falls of rock in mining accidents, or by the crushing force of railway collisions.

When broken, the pelvis usually gives way at the rami of the pubes and ischium in front, and across the ilium, at or near the sacro-iliac synchondroses, behind, usually on the side opposite to that of the fracture in front. The pubis may be, but rarely is, broken across its body, and the symphysis is seldom torn through. When one side of the pelvis is thus broken away from the rest of the bone, it and the attached lower extremity are necessarily connected with the rest of the body only by the soft parts that connect the pelvis to the spinal column and trunk. These are consequently liable to severe stretching, laceration, and other injury.

In some cases, portions of the crest of the ilium only are detached. In others, the rami in front may be broken without corresponding posterior fracture. Such injuries can, however, arise only from gun-shot-wounds or similar forms of direct violence. When the fracture results from a crush, double fracture, back and front, must necessarily occur.

The main and immediate danger in fracture of the pelvis, indeed, is due to the concomitant or consequent injury to the very important soft parts contained within its cavity. Muscles, nerves, and blood-vessels may be stretched or torn. The bladder may be wounded by a spiculum of bone from the pubes

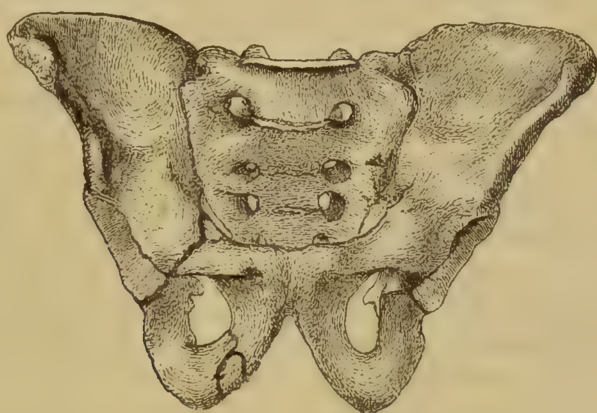


Fig. 223.—Fracture of the Pelvis through Rami in front, and Sacro-iliac synchondrosis behind.

or ischium; or the urethra may be torn, perhaps completely across, from the same cause. When the urethra is torn, a slight oozing of blood will usually be observed at its orifice, with possibly much and deep ecchymosis of the perinæum.

The nature of the injury is usually apparent from the great degree of direct violence that has been inflicted upon the part; from the pain that the patient experiences in moving or in coughing; from the inability to stand, in consequence of a feeling as if the body were falling to pieces when he attempts to do so; and from the ready mobility of the part and crepitus on seizing the brim of the pelvis on each side and moving it to and fro, or on rotating the thigh of the affected side. In examining a patient with suspected fracture of the pelvis, care should, however, be taken not to push the investigation too closely, lest injury be inflicted by the movement of the fragments. In those cases, indeed, in which the fracture does not extend completely across the pelvis, or in which it is seated in the deeper parts of the ischium, an exact diagnosis may be very difficult, and should not be attempted.

Treatment.—As the great danger in fracture of the pelvis consists in the

possibility of the bladder having been wounded, or the urethra torn, the first thing to be done is to pass a gum-catheter. If the urine comes clear, it may be concluded that the urinary apparatus has not been injured, and the catheter may be withdrawn. If it is bloody, the catheter must be tied in, and an india-rubber tube applied by which the urine may drain away. The next thing is to keep the part perfectly quiet, so as to bring about union. With this view, a padded belt, or a broad flannel-roller, should be tightly applied round the pelvis, the patient lying on a hard mattress. The knees may then be tied together, and a leather- or gutta-percha-splint moulded to the hip of the side affected, so as to keep the joint quiet, and to prevent all displacement of the fragment. If the urethra have been lacerated, it must be borne in mind that, however completely the patient may recover from the fracture, he will most certainly eventually become the subject of the most troublesome and intractable form of urethral stricture—the traumatic.

Period of Union.—Bony union usually takes place in the pelvis about the end of the sixth week. The patient must, therefore, be kept on his back with absolute immobility and fixity of the limb on the injured side, for at least seven to eight weeks. He may then, wearing a padded belt, move on crutches, but must not be allowed to bear any weight on the foot of the affected side for some weeks more, lest the detached fragment be pushed upwards. However good the union may be, lameness is apt to result from the injury inflicted on the psoas and iliacus muscles, and those that closely bind the thigh to the pelvis, such as the pectineus, the obturators, &c.

Fracture of the Acetabulum is an accident that can occur only as the result of very great violence directly applied to the hip. It may take place in two situations; either through the floor of the cavity, or only through the rim, a portion of which is detached. It is probably occasioned in most instances by the head of the thigh-bone being driven forcibly against the surface of the acetabulum. Hence, when the rim is broken, it is usually the posterior part that is detached, and the head of the femur slips out upon the dorsum ilii.

Fracture through the floor of the acetabulum is usually complicated with such extensive comminution of the pelvic bones and serious internal injury, as to be followed by death. In the University College Museum is a preparation of a fracture of the acetabulum, with comminution of its floor and of the ilium. Sanson and Sir A. Cooper have seen the bone resolved into its three primitive parts; and in some cases the comminution has been so great that the head of the femur has been thrust into the pelvic cavity.

In such extensive and grave injuries as these, the Surgeon can do little more than support the pelvis with a padded belt, and place the limb on a long splint.

When a portion of the rim of the acetabulum is detached, as the result of direct violence, the head of the femur will slip out upon the dorsum ilii, and the signs of one of the forms of dorsal dislocation manifest themselves. In a case of this kind, which was under my care at the Hospital in a muscular man aged about thirty, the shortening and inversion of the limb and displacement of the head of the bone towards the sciatic notch, were all well marked. Traction readily effected reduction, with distinct crepitus; but, as soon as extension was discontinued, the head of the bone slipped back into its former position. The diagnosis in this case was made, and in similar instances may

readily be effected, by attention to three circumstances:—the dislocation, its ready reduction with crepitus, and its immediate return when the limb is left to itself.

The **Treatment** consists in the application of the long splint with a broad padded belt, so as to secure steadiness of the head of the bone. But with every care a return of displacement will readily take place, and an unsatisfactory result can scarcely be avoided; shortening of the limb, and consequent lameness, being almost inevitable.

Fractures of the Sacrum are excessively rare, except as the result of gun-shot-injury. When occurring from other causes, such as falls, they are almost invariably associated with fracture of the pelvic bones, and then they have always been fatal. The records of surgery contain but a very few observations, probably not more than six or eight, of uncomplicated fracture of the sacrum arising from other causes than gun-shot. I have had two cases of fracture of the sacrum under my care. Both had a rapidly fatal issue. In one there was also fracture through the pubic bone; in the other, the sacrum was the only bone injured. In it, the fracture was the result of a blow on the lower part of the back by the buffer of a railway carriage. The preparation is in the University College Museum. The only other preparation with which I am acquainted, is one in the Museum of the College of Surgeons. These fractures are almost invariably transverse, with displacement forwards of the upper margin of the lower fragment. This was the case in both the instances under my care; but Richerand has published a case in which this bone was split vertically in consequence of a fall on the face; and its crucial and multiple fracture have been described by others. The injury can necessarily arise only from direct violence of a severe character, and is attended by much extravasation and pain, together with neuralgia along the course of the posterior sacral nerves, which may be implicated in or irritated by the fracture. The *Treatment* is as for fractured pelvis, and should consist in the application of a padded pelvic band.

The Coccyx, though more exposed, is seldom broken. But fracture of it may occur from falls backwards, or from direct blows on the part, the tip being bent forcibly forwards, and the elements of the bone separated. The displacement forwards is maintained by the action of the coccygei. The pain in these cases is excessively severe, owing to the bruising of the ligamentous and tendinous expansions that cover the bone. It is greatly increased in sitting and walking, and in defæcation, or in any violent expiratory effort, as sneezing or coughing. It is sometimes removed on reducing the fractured and displaced fragments by pressure through the rectum, but may continue for months, and even longer, constituting a truly neuralgic affection of the part. South relates the case of a gentleman who broke his coccyx by sitting on the edge of a snuff-box, and who suffered such severe pain that he was obliged to wear a pad on the tuberosity of each ischium, in order that the coccyx might be in a kind of pit, free from pressure when he sat.

Under the term **Coccydynia,** Sir J. Y. Simpson has described a painful affection of the coccyx and its neighbouring structures, which occurs chiefly in women, commonly as the result of injury, and is often very severe and persistent, so as to prevent the patient from sitting, or even walking with comfort. It is an affection that closely resembles in its symptoms the pain occasioned by fissure or ulcer of the anus and rectum. It usually arises from a blow on the

part. It appears sometimes to originate independently of external violence, and is then probably due to retroversion of the uterus.

In some cases the coccyx may be in its normal position, but in others the whole bone is found to have been displaced by the injury which caused the affection, and to be projecting forwards almost at right angles to the sacrum. It can be felt from the rectum, causing a distinct projection into the bowel. It is maintained in its abnormal position chiefly by the action of the coccygei. This condition is in fact rather a dislocation than a fracture. The bone can easily be forced into its normal position with the finger from within the rectum, but it returns again to its former position immediately the pressure is removed.

The **Treatment** recommended by Sir J. Y. Simpson consists in the free subcutaneous division, by means of a tenotome, of the muscular and tendinous structures connected with the coccyx. The section of these structures is made first on one side, then on the other, and finally around the tip, so as completely to isolate the bone. I have often performed this operation, and have as often as not been disappointed in the results. When it succeeds the good effects are immediate. When it fails it has been recommended to remove the bone by a longitudinal incision over its middle, exposing its posterior surface. This operation is free from danger, but most uncertain in its results.

Fractures of the Thigh-Bone are of great practical interest, from their frequency and severity. They may occur in the Upper Articular End of the bone, in its Shaft, or in its Lower End. In these different situations, every possible variety of fracture is often met with.

1. **Fractures of the Pelvic End of the Bone** may be divided into those that occur *through the Neck Within the Capsule* of the joint, those that occur *Outside the Capsule*, and those that implicate the *Trochanters* alone.

Intracapsular Fracture of the Neck of the Thigh-Bone may be either simple, the bone being merely broken across ; or impacted, the lower portion of bone being driven into the upper fragment.

This intracapsular fracture may almost be looked upon as a special injury of advanced life, being but seldom met with in persons under fifty. Thus Sir A. Cooper states that, of 251 cases with which he met in the course of his practice, only two were in persons below this age. It may, however, happen at an early period of life ; Stanley has recorded the case of a lad of eighteen, who met with this injury, and Hamilton has described it as occurring in a girl aged sixteen and in a man aged twenty-five. A remarkable circumstance in connection with this accident is, that it commonly happens from very slight degrees of violence, indeed almost spontaneously. Thus, the jarring of the foot in missing a step in going downstairs, catching the toes under the carpet, tripping upon a stone, or entangling the foot in turning in bed, are sufficient to occasion it. Women are most liable to this injury.

Cause.—The occurrence of this fracture in old age is owing indirectly to the changes in structure, shape, and position of the head and neck of the femur with advancing years. The cancellous structure of these parts becomes expanded, the spaces large, loose, and loaded with soft fat. The compact structure becomes thinned, and proportionately weakened, especially about the middle and under part of the neck, which, appearing to yield to the weight of the body, is shortened ; and, instead of being oblique in its direction, becomes horizontal, inserted nearly at a right angle into the shaft. In consequence of

these changes in structure and position, it becomes less able to bear any sudden shock by which the weight of the body is thrown upon it, and snaps under the influence of very slight degrees of violence. When it breaks, the capsule may remain uninjured, but the prolongation of it which invests the neck of the bone is usually torn through. In some cases, however, this cervical reflection is not ruptured, the lower portion of it, especially, often remaining for some length of time untorn, at last, however, giving way under the influence of the movements of the limb, or from inflammatory softening. As the violence occasioning the fracture is generally but slight, and as the vascularity of this portion of the bone is trifling in old people, there is but little extravasation of blood.

The fragments are almost always so separated that the fractured surfaces are not in apposition: the upper end of the lower fragment is drawn above

Fig. 224.—Intracapsular Fracture of the Neck of the Femur.

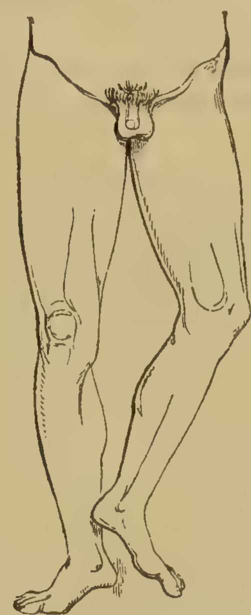


Fig. 225.—Attitude of Limb in Intracapsular Fracture of the Neck of the Thigh-Bone.

and behind the head of the bone, and at the same time is twisted so that its broken surface looks forwards. The head remains in the acetabulum, attached by the ligamentum teres, and sometimes preserving a connection with the lower fragment, through the medium of some untorn portions of the fibrous membrane investing the neck. R. W. Smith has observed, that in some instances the two fragments become interlocked or dovetailed as it were into one another, in consequence of the line of fracture being irregular and dentated.

Signs.—These are, alteration in the shape of the hip, crepitus and pain at the seat of injury, and inability to move the limb, with shortening and eversion of it. These we must consider separately, as important modifications of each are sometimes noticed. From the indirect nature of the violence which caused the injury there are no signs of superficial bruising over the hip.

The **Alteration in the Shape of the Hip** is evidenced by some flattening of the part, the trochanter not being so prominent as usual. This process is

also approximated to the crest of the ilium; and, on rotating the limb, it is felt to move to and fro under the hand, not describing the segment of a circle so distinctly as on the sound side. The circle described by the trochanter on the injured side is much smaller than that on the sound side. In the sound limb, the trochanter describes the segment of a circle having a radius equal to the length of the head and neck of the bone; on the injured side, the circle has a radius equal only to the length of that portion of the neck that still remains attached to the shaft of the bone. During this examination *crepitus* will usually be felt, though this occasionally is very indistinct and even absent, more especially if the limb be not well drawn down at the time it is rotated, so as to bring the fractured surfaces into apposition; and much *pain* is produced by any movement of, or pressure upon, the joint.

The **Attitude of the Limb** is so peculiar, as in general to indicate at once to the Surgeon what has happened. There is a striking appearance of helplessness about it. As the patient is lying on his back in bed, it is everted; shortened somewhat, with the knee semi-flexed; on requesting him to lift it up, he makes ineffectual attempts to do so, and at last ends by raising it with the toe of the opposite foot, or with his hands. When he is taken out of bed and placed upright, the injured limb hangs uselessly, with the toes pointing downwards, and the heel raised and pointing to the inner ankle of the sound side, the patient being unable to rest upon it (Fig. 225). In some cases, however, after the fracture has occurred, the patient can lift the limb somewhat, but with much exertion, from the couch on which he is lying; or can even manage to walk a few paces, or to stand for a few minutes upon it, with much pain and difficulty. This is owing either to the cervical reflection of the capsule being untorn, or else to the fragments not being separated, having become locked into one another; and it usually occurs in those cases in which the other and more characteristic signs of this fracture are not well marked.

Eversion of the limb is almost an invariable accompaniment of this fracture. It is most marked in those cases in which the shortening is most considerable. This eversion has usually been attributed to the action of the external rotator muscles, which are inserted into the upper end of the lower fragment. But I cannot consider this as the only, or indeed the principal cause of this position; for, not only is it very difficult to understand how these muscles can rotate the limb outwards after their centre of motion has been destroyed by the fracture of the neck of the femur, their action being rather in a direction backwards than rotatory under these circumstances; but we find that the limb falls into an everted position in those cases in which, the fracture being in the shaft, and altogether below the insertions of these muscles, no influence can be exercised by them on the lower fragment. I look upon eversion in cases of fractured thigh as not being a result of muscular action at all, but simply the natural attitude into which the limb falls when left to itself. Even in the sound state, eversion takes place spontaneously whenever muscular action is relaxed, as during sleep, in paralysis, or in the dead body; and in the injured limb, in which there is, as it were, a suspension of muscular action, it will occur equally. Indeed, the shortening that takes place will specially tend to relax the external rotators, and thus still more prevent their influencing the position of the limb.

Inversion of the foot in cases of intracapsular fracture has been sometimes

noticed. I have seen two instances: Smith, Stanley, and other Surgeons, have also recorded cases. This deviation from the usual symptoms of this injury has been attributed by some to the cervical ligament not having been torn through at its inner side, but that, as Stanley observes, while it may prevent eversion, cannot occasion inversion; by others to the fact of the lower fragment in these cases being found always in front of the upper one. This circumstance, which is much insisted on by R. W. Smith, appears to me to be rather the result than the cause of the inversion; for any traction inwards of the lower fragment by the adductor muscles of the thigh would have a tendency to draw the upper end of this fragment to the anterior, or in other words, the inner side of the upper one. I am rather disposed to think that this inversion is owing, in some cases at least, to the external rotators being paralysed by the violence they receive from the injury that occasions the fracture, and that thus the adductors, acting without antagonists, draw the thigh and with it the leg inwards. In both instances that fell under my observation, and in some of those that have been published, the fracture resulted from severe direct injury to the hip, and was not occasioned by the patient jarring his foot, or by any indirect violence operating at the end of the limb.

The **Shortening** in cases of fracture within the capsule seldom exceeds, in the first instance, from half an inch to an inch, depending on the extent of the separation between the fragments; it cannot, indeed, in the early periods of the fracture, very well exceed the width of the neck of the bone, as the capsule is usually not torn through. After the fracture has existed some time, the capsule of the joint may yield, allowing greater separation between the fragments, and then it may amount to two, or even two and a half inches. It not uncommonly happens that the shortening, which is at first but very slight, about half an inch, suddenly increases to an inch or more; this is accounted for on the supposition of the cervical ligament, which had not been at first completely ruptured, at last giving way entirely; or it may be owing to the fragments which were originally interlocked becoming separated. It is in those cases in which there is but slight separation of the fragments, and consequently little shortening, that the other signs of fracture are not very strongly marked, and that the patient preserves some power over the movements of the limb.

The **Constitutional Disturbance** in intracapsular fracture of the neck of the femur in old people, though trifling at first, often eventually becomes considerable; and the injury frequently terminates fatally, from the supervention of hypostatic pneumonia, an asthenic state of system, or sloughing of the nates from confinement to bed during treatment. Hence this injury must always be considered as very dangerous, and not unfrequently fatal.

Mode of Union.—The treatment of these fractures turns in a great measure upon the view that is taken of their mode of union, and on the constitutional condition of the patient. In some cases no union occurs, but the head of the bone remains in the acetabulum, being hollowed into a smooth, hard, cup-shaped cavity, in which the neck, which has become rounded off and polished, is received, and plays as in a socket. In the great majority of cases, however, union takes place by fibrous tissue. This is owing to two causes; in the first place, to the circumstance (which I look upon as the most important) that the fractured surfaces are not in apposition with one another; and secondly, that the vascular supply sent to the head of the bone, consisting only of the blood

that finds its way through the vessels of the ligamentum teres, is insufficient for the proper production of callus.

In some cases, however, bony union does take place. This can happen only when, in consequence of the cervical ligament being untorn, or the fracture being impacted, the surfaces are kept in some degree of apposition, and the supply of blood to the head of the bone is speedily augmented by that carried to it through the medium of the vascular tissue formed between the fragments in the process of repair. In no other circumstance is it probable that osseous union takes place in these fractures : hence the infrequency of its occurrence, there being in all probability not more than eighteen or twenty cases on record as having thus terminated in this country. When bony union does take place, the head of the femur will usually be found to be somewhat twisted round in such a way that it looks towards the lesser trochanter, owing to the eversion that has taken place in the lower fragment.

Treatment.—As these fractures do not unite by bone unless the fragments be in good contact, it is useless to confine the patient to bed for any long period, if the signs, especially the amount of *shortening*, indicate considerable separation between the fragments, or if the patient be very aged and feeble. In these circumstances, lengthened confinement to bed most commonly proves fatal by the depressing influence which it exercises on the general health, causing hypostatic pneumonia or inducing bed-sores. It is therefore best to keep the patient in bed merely for two or three weeks, until the limb has become somewhat less painful, and the tendency to muscular spasms, often very distressing, has passed away. The patient should be laid flat on the back, on a fracture-bed or a suitable couch properly provided with a pan for the reception of the excreta. This is most important, for if the urine and fæces be passed under the patient so as to wet the buttocks bed-sores will infallibly result. In fact the utmost attention to dryness and to cleanliness is needed in order to prevent them. The knees should be bent at an angle of 45° over pillows and the legs tied together. At the end of from two to four weeks a leather splint should be fitted to the hip, and the patient be allowed to get up upon crutches. There will be lameness during the remainder of life ; but, with the aid of a stick and properly adjusted splint, but little inconvenience will be suffered.

Another mode of treatment which will be found extremely useful is the early application of a well-fitted Thomas's hip splint. (See Diseases of Hip Joint.) Until the splint is ready the patient may be kept in bed, either with the legs bent, as before described, or with a weight extension apparatus (Fig. 235) to diminish shortening, and sand-bags to steady the limb and prevent eversion. The splint may safely be applied at the end of a fortnight, and the patient may then leave his bed and move about on crutches.

When the fragments do not appear to be much separated, there being but little shortening and indistinct crepitus, and more particularly if the patient be not very aged, and in other respects sound and well, an attempt may be made to procure osseous or at least close ligamentous union. This may be done by the application of the long thigh-splint, in the same way as for a fracture of the shaft ; or, if this cannot very readily be borne, by the double inclined plane, with a padded belt strapped round the hips. This apparatus may be replaced by a Thomas's hip splint at the end of a month or five weeks, and the patient allowed to get up. If the Thomas's splint cannot be obtained, or

cannot be borne, the patient must be kept in bed for at least two or three months, when a leather splint may be put on, and he may move about on crutches. During the whole of the treatment, a generous, and even stimulating diet should be ordered, and the patient kept on a water-bed or cushion. In these fractures of the neck of the femur, the starched bandage will often be found to be most useful. It may be applied as in fractured thigh, but should have additional strength in the spica part, and indeed may be provided with a small pasteboard cap so as to give more efficient support. When the patient begins to move about, great comfort will be derived from the use of a well-padded leather or gutta-percha case, made in two pieces, one for the hip, the other for the thigh, united by a hinge-joint, which can be set fast in the erect posture by dropping a slot over it. When this is raised it can be flexed, and so admit of the patient sitting in comfort. In old people, this plan of treatment is especially advantageous, as it enables them to sit up or even to walk about, and thus prevents all the ill effects of long confinement in bed.

Impacted Intracapsular Fracture is a rare accident, and can scarcely be distinguished from a similar injury outside the capsule. In it the upper end of the neck is driven into the cancellous tissue of the separated head. In a case under the care of Gay, of the Massachusetts General Hospital, which is recorded by Bigelow, the nature of the injury was proved by post-mortem examination, death having occurred from pneumonia at the end of two weeks. The following were the symptoms. The patient, aged 76, fell, striking the right trochanter. He thought he had received only a bruise, and crawled upstairs to bed unaided. Two days after, when admitted to the hospital, the right leg was found to be shortened half an inch ; the foot was everted, and could not be inverted beyond the perpendicular ; the thigh could be flexed and extended without difficulty, but with pain ; the trochanter was less prominent than that of the other side. Before he died he could raise his foot some inches from the bed without assistance. After death the head was found to be "broken from the articular extremity of the neck, which was short and thick, the fracture behind being almost at the line of junction of the articular cartilage and the bone, while in front it ran irregularly across the neck from a quarter to half an inch below this line. The head was bent obliquely backwards and downwards towards the lesser trochanter—the tilting of the head opening the fracture on the outside of the neck—and was so firmly impacted that considerable force was required to withdraw it." Bigelow records also a case under the care of Cushing, of Dorchester, U.S.A., in which the exact nature of the impacted fracture was proved by examination after death, which occurred nearly five years after the accident. The patient was seventy years of age. The fracture closely resembled that just described, and union had taken place by bone. It is evident that these cases cannot be distinguished during life from impacted fractures of any other part of the neck. The *treatment* is the same as that of extracapsular impacted fracture.

Extracapsular Fracture of the Neck of the Thigh-Bone is commonly met with at an earlier period of life than the injury which has just been described, being most frequent between the ages of thirty and forty, but it is met with also at advanced periods of life. It is the result of the application of direct violence to the hip, and is equally common in both sexes. In young subjects it occurs only as a consequence of great violence, but in old people it may result from a simple fall on the hip.

This fracture may be of two kinds; the *simple*, or the *impacted*. In both cases the neck of the bone is commonly broken at, or immediately outside, the insertion of the capsule of the joint. The fracture is almost invariably comminuted when it occurs in a young subject or as the result of great violence. Indeed, I have never seen a case of this kind in which the great trochanter was not either detached or splintered into several fragments. In many instances the lesser trochanter is detached, and the upper end of the shaft injured (Fig. 226). This splintering of the trochanter is owing to the same violence that breaks the bone, forcing the lower end of the neck into the cancellous structure of this process, and thus, by a wedge-like action, breaking it into fragments. When the neck continues locked in between these, we have the impacted form of fracture. In older subjects, however, whose bones are atrophied and softened by age, it is common to meet with extracapsular impacted fractures without any splintering of the trochanter.

Fig. 226.—Simple Extracapsular Fracture of the Neck of the Thigh-Bone: Detachment of the Trochanter.

The *Signs* of extracapsular fracture vary according as it is simple or impacted; but in both cases they partake of the general character of those of fracture within the capsule. The individual signs, however, present certain well-marked differences.

The hip will usually be found much *bruised and swollen* from extravasation of blood, which is often considerable.

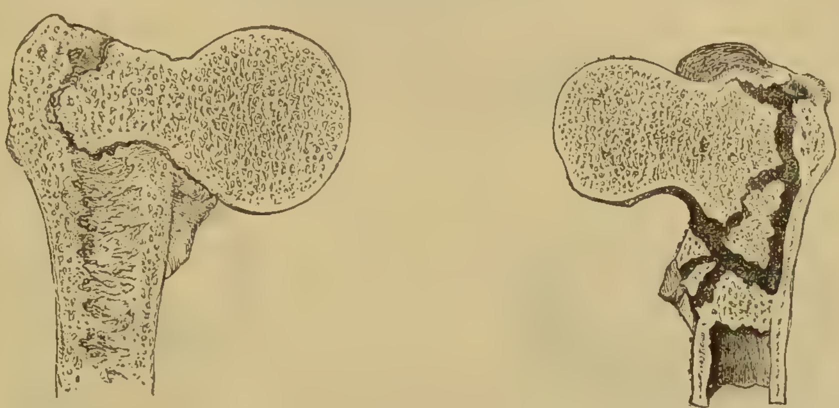
In the **unimpacted fracture,** the *crepitus* is very distinct and loud, being readily felt on laying the hand upon the trochanter, and moving the limb. The separate fragments into which the trochanter is splintered may occasionally be felt to be loose. The *pain* is very severe, and greatly increased by any attempt at moving the joint, which to the patient is impossible. The *eversion* is usually strongly marked, and the position of the limb is characteristic of complete want of power in it. *Inversion* occurs more frequently in this fracture than in that within the capsule. Smith finds that of 7 cases of inversion of the limb in fractures of the neck of the femur, 5 occurred in the extracapsular fracture; and of 15 cases of intracapsular fracture, this condition was met with in 3. When there is much comminution of the trochanter, the foot will commonly remain in any position in which it is placed, but generally has a tendency to rotate outwards. The *shortening* of the limb is very considerable, being never less than from an inch and a quarter to two inches and a half, or three inches.

In the extracapsular fracture of the neck of the femur, death not uncommonly results from the severity of the injury, the pain and irritation of the fracture, and the consequent shock to the system. The great extravasation of blood into the tissues of the limb has been known to be sufficient to account for the fatal result. When the patient lives, bony union takes place, large irregular stalactitic masses being commonly thrown out by the inferior fragment, so as to overlap the several splinters of bone and thus give the appearance of great thickening and projection of the trochanter. This callus is most abundant posteriorly in the intertrochanteric space (Fig. 230).

The **Impacted Extracapsular Fracture** of the neck of the thigh-bone occurs when, in consequence of a heavy fall on the hip, the neck is broken

across at its root, and the upper fragment is driven into the cancellous structure of the lower one, often splitting up and detaching the trochanter (Figs. 227, 228). It is not an uncommon accident about middle life, and even in old age. Its most common cause is a sudden severe fall, as upon the ice in skating.

The *Signs* of this form of fracture are often somewhat negative, rendering its diagnosis extremely difficult. There is *pain* about the hip, with *eversion* of the foot. The degree of eversion varies considerably ; sometimes it is so great that the outer side of the foot can scarcely be raised from the bed without giving the patient intense pain, and in other cases it can be recognized only by the limitation of inversion when contrasted with the opposite limb. There is slight *shortening*, usually about half an inch, and never exceeding one inch, and occasionally as little as a quarter of an inch. As a rule, there is no *crepitus*. but occasionally, owing to the looseness of the impaction, some may be obtained



Figs. 227, 228.—Sections of Impacted Extracapsular Fractures of Neck of Femur ; showing the degree of Impaction and of Splintering in different cases.

with difficulty. When the impaction is firm, the patient can raise the foot a few inches off the couch on which it is laid, and even walk a short distance upon it with a hobbling motion, though with much pain. Some flattening over the trochanter is usually perceptible ; sometimes an increase in breadth from before backwards. In consequence of the impaction the limb cannot be restored by traction to its proper length, and hence incurable lameness always results from this injury.

Pathology.—The deformity accompanying this injury has been shown by Bigelow to be due in great measure to the anatomical structure of the femur. If a series of horizontal sections be made of the neck of the bone, "it will be found that at the upper part the anterior and posterior walls are of nearly equal thickness, but that as we approach the lower surface, the anterior wall becomes of great thickness and strength, while the posterior wall remains thin, especially at its insertion beneath the posterior intertrochanteric ridge, where it is of the thinness of paper." The result of this is, that when severe direct violence is applied to the trochanter the posterior wall yields, crushes up, and becomes impacted, while the anterior "serves as a sort of hinge upon which the shaft rotates to allow the posterior impaction." This causes the rotation outwards. The shortening Bigelow explains by obliquity of the neck of the femur, which causes the limb to be shortened in proportion to the rotation. That this is the true explanation of the deformity in all the slighter cases of

this injury is undoubtedly true. In the more severe crushes of the trochanter, the anterior wall of the neck as well as the posterior may be driven amongst the splintered fragments.

The *Treatment* of the extracapsular fracture may very conveniently and efficiently be conducted by means of the long splint, a padded belt, if necessary, being strapped firmly round the hips underneath it ; or the plan recommended by Sir A. Cooper, of placing the patient on a double inclined plane, with both feet and ankles tied together, and a broad belt, well-padded, firmly strapped round the body, so as to press the fragments of the trochanter firmly against one another, will be found an excellent mode of keeping the limb of a proper length, and the fragments in contact. In impacted extracapsular fracture nothing can be done to diminish the deformity. Solid bony union always takes place, even in aged subjects. The patient remains throughout life more or less crippled, chiefly by the eversion, the amount of shortening being of little consequence. The patient may have a Thomas's splint applied after resting in bed till the swelling and pain have subsided ; or a leather splint may be applied at the end of the third week, and he may be allowed to move about on crutches.

The **Diagnosis** of the different forms of fracture of the neck of the thigh-bone from one another, and from other injuries occurring in the vicinity of the

Fig. 229.—Union in Impacted Extra-capsular Fracture of Neck of Femur.

Fig. 230.—Impacted Extracapsular Fracture of Neck of Femur: Abundant Formation of Callus.

hip-joint, is a matter of considerable importance, and often of no slight difficulty. The ordinary method of measuring the limb is to apply one end of the tape to the anterior superior spinous process of the ilium, and the other to the inner malleolus. The two limbs must be put as accurately as possible in the same position, as flexion and extension will considerably alter the distance between these points. Two other methods have been recommended for more accurately determining the position of the trochanter, both of which are of great diagnostic value in injuries, whether fractures or dislocations, of the hip. The first is known as Nélaton's line ; the second, as Bryant's ilio-femoral triangle.

Nelaton's Diagnostic Line (Fig. 231, dark line) consists of a line drawn from the anterior superior spine of the ilium to the tuber ischii. If the trochanter be at its proper level, this line ought to touch its upper border when the limb is straight. The importance of this line is, that when the head of the femur is in its normal situation, it touches the summit of the trochanter

in every degree of flexion or extension of the limb. If the trochanter be displaced in any direction, a corresponding change in its relation to this line will ensue. This mode of measurement is, however, open to the fallacy that

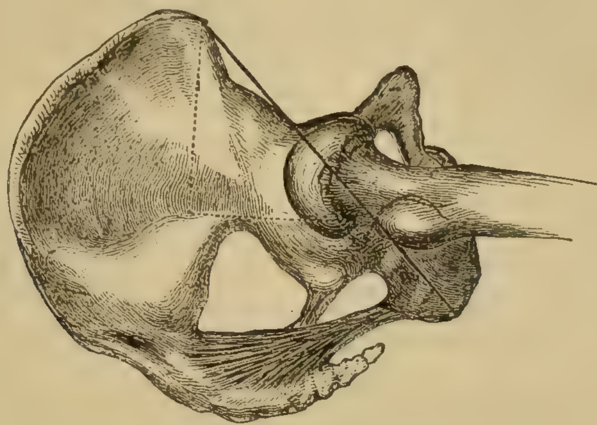


Fig. 231.—Nélaton's Line—dark. Bryant's Ilio-femoral Triangle—dotted.

abduction raises the trochanter above the line, and adduction brings it below it.

Bryant's Ilio-femoral triangle (Fig. 231, dotted line) is formed by placing the patient in the recumbent position; then, drawing a line from the anterior superior spine of the ilium directly backwards, another line also from the anterior superior spine obliquely to the summit of the trochanter, and a third, or the base-line, directly upwards from this to the first line, a triangle will thus be formed. The oblique line corresponds to the first part of Nélaton's line (Fig. 231), and may be taken, just as Nélaton's, as the diagnostic line for dislocations for the head of the femur backwards; whilst Bryant's base-line is the test-line for all cases in which the neck of the femur is shortened, or the head of the bone thrown upwards. In this method of measuring there is the same fallacy—that abduction and adduction of a healthy limb would alter the length of the base line.

Another method of measurement has been recommended by Giraud-Teulon which, although somewhat complicated, appears to be free from all source of error. It is founded upon the fact that the middle of Nélaton's line corresponds to the centre of the acetabulum. Any shortening of the femur by fracture, or any dislocation, will necessarily alter the distance between the lower end of the femur and this point. The measurement is thus carried out. Find the distance from the anterior superior spinous process to the tuberosity of the ischium, and from the same point to the inner condyle, and from the tuberosity to the inner condyle. Then draw a triangle on a sheet of paper, the three sides of which are equal to these three measurements; find the middle point of the line corresponding to the measurement between the tuberosity and the spine, and from that draw a line to the apex of the triangle. This line corresponds to the distance of the inner condyle from the centre of the acetabulum, and must be contrasted with a similar line obtained by measurement of the sound side. This mode of measurement is most useful in cases of dislocation and disease in which abduction or adduction with flexion are often met with.

Whatever mode of measurement is adopted, the Surgeon must never neglect

to examine and compare the two sides carefully and simultaneously, with one hand on each hip.

Between the unimpacted intracapsular and the ordinary extracapsular fractures there can be no difficulty in diagnosis ; all the signs of the latter being much more strongly marked than those of the former injury, as may be seen by the annexed table, the difference of age and the degree of violence required to break the bone being also important elements in the diagnosis.

Diagnosis between unimpacted Intra- and Extra-capsular Fractures of the Neck of the Thigh-bone.

Intracapsular.	*Extracapsular.*
1. Cause generally slight and indirect, such as catching the foot in the carpet or slipping off the curb-stone.	1. Cause usually severe and direct violence, such as falling from a height or a blow on the hip.
2. Force usually applied longitudinally or obliquely.	2. Force usually applied transversely.
3. Age, rarely below fifty ; most commonly in feeble aged persons.	3. Age, usually below fifty ; chiefly in vigorous adults.
4. Pain and constitutional disturbance slight.	4. Pain and constitutional disturbance usually considerable.
5. No apparent injury to soft parts about hip.	5. Considerable extravasation, ecchymosis, and signs of direct injury to hip.
6. Crepitus often obscure.	6. Crepitus, very readily felt.
7. Shortening, at first, usually not more than one inch.	7. Shortening at least two inches or more.

The distinction between *intracapsular fracture* and the *impacted fracture of the neck* is also easy. In the former case the crepitus can be obtained by extending and rotating the limb, the eversion is more marked, and the injury occurs usually from indirect violence ; in the latter, traction cannot restore the limb to its proper length, crepitus is wanting, and the fracture is always the result of direct violence applied to the trochanter.

In *impacted fractures of the neck of the femur* it is, as a rule, impossible to determine whether the injury is within or without the capsule. The separation of the head and the impaction of the neck into it occurs only in old people, and, judging from the few recorded cases, the shortening and eversion are slight. Fracture of the root of the neck with impaction into the trochanter occurs at all ages after middle life. Its symptoms vary from scarcely appreciable displacement to extreme eversion with one inch of shortening. Should the trochanter have been fissured or splintered, this may be ascertained on careful examination, and the nature of the injury could then be recognized with certainty.

Severe contusions of the hip are sometimes followed by eversion of the limb with inability to move it, so that at first sight it might be supposed that the bone was broken. In these cases, however, the absence of immediate shortening and crepitus will aways establish the diagnosis. But though no immediate and sudden shortening can occur without fracture, these contusions may be followed at a remote period by shortening of the limb from atrophic changes in the head and neck of the femur. When the injured hip-joint has been the seat of *chronic rheumatic arthritis*, and the limb is already somewhat shortened by the changes that occur in the head and neck of the femur in this disease, the difficulty of diagnosis becomes great ; especially as there may also be, as the result of the disease, some thickening of the trochanter, with rough

grating, almost like true crepitus, on moving the joint. Here, however, the history of the case, the fact of the shortening not being of recent occurrence, the possible affection of other joints and the character of the grating will be sufficient to establish the nature of the injury. The diagnosis of these injuries from *dislocations* will be considered in a subsequent chapter. Occasionally the fracture extends **through the trochanter major and upper part of the shaft** without implicating the neck of the bone. Here there is shortening to about three-fourths of an inch, or an inch, with much eversion, and crepitus readily felt. This fracture, which unites firmly and well by bone, must be treated in the same way as the last.

Compound Fractures of the Neck of the Thigh-bone can occur only from bullet-wounds. In these cases the choice lies between amputation at the hip-joint, resection of the injured portion of bone, or treating the case as an ordinary compound fracture. The choice of the Surgeon, for reasons stated at p. 342, lies between the latter two alternatives, which are the only ones that afford a reasonable hope of safety to the patient.

Fracture of the Trochanter Major, by which this process is broken off from the rest of the bone, is described by Sir Astley Cooper, Aston Key, and Nélaton as being always the result of direct violence. It may be simple or comminuted. The fragment is usually drawn upwards and backwards, rarely forwards ; and more rarely it remains fixed by fibrous bands in its normal place. The symptoms are, separation between the fragments ; and crepitus, which is most readily obtained by flexing and abducting the thigh and rotating it outwards, at the same time that the fragments are firmly pressed together. There is no shortening of the limb. The exact nature of the injury is often concealed by the swelling from extravasated blood. The fracture is very rare without accompanying fracture of the neck.

In children the epiphysis of the trochanter has been known to be separated by direct violence.

2. **Fractures of the Shaft of the Thigh-bone** are of very common occurrence, every possible variety of the injury being met with here. They are extremely common in children, forming, according to Bruns, one-quarter of all fractures in children under ten. They steadily decrease in frequency with age. Excluding fractures of the neck, one-third of all fractures of the femur occur under ten, and about the same between 10 and 30.

In adults they are always oblique, unless they are the result of direct violence : in children, especially when the child is very young, the fracture is more often transverse or nearly so. The most common seat of fracture from indirect violence is the middle third, and the obliquity is such that the sharp point of the upper fragment is directed forwards and outwards.

The *Signs* are well marked. There is shortening, usually to a considerable extent, with eversion of the limb, crepitus readily produced, and much swelling from the approximation of the attachments of the muscles. The lower fragment is always drawn upwards, and somewhat to the inner side of the upper one, and is rotated outwards. When the fracture is at or above the middle of the thigh, there is a great tendency to angular deformity, in consequence of the projection forwards of the lower end of the upper fragment. In all cases there is this forward projection, and in most an outward displacement, or abduction, as well of the upper fragment. But in some very rare cases, it is drawn inwards as well as forwards.

I have taken three opportunities of ascertaining by dissection the condition of parts that leads to the projection forwards and lateral displacement of the lower end of the upper fragment in fracture of the femur. The first case was that of an old man who died about three hours after meeting with a compound comminuted fracture of the middle and lower thirds of the right thigh-bone, and in whom this displacement of the upper fragment was very distinctly marked. It was found that the gluteus maximus and medius could be divided without affecting the position of the bone; but when the gluteus minimus was cut across, it yielded somewhat. The pyriformis and external rotators were now felt to be excessively tense; and, on cutting these across, the end of the fragment could at once be drawn inwards, all opposition ceasing. The projection forwards still remained, however; and this, which was evidently due to the tension of the psoas and iliacus muscles, yielded at once on dividing them. It would thus appear that there must be a double displacement of the upper fragment; outwards, depending on the action of the external rotators; and forwards, owing to the contraction of the psoas and iliacus muscles.

The second case was one of displacement forwards and inwards. It was that of an elderly man, who died of internal injuries about half an hour after meeting with fracture of both thigh-bones, at the junction of the upper and middle thirds, by the passage of a cart-wheel across the thighs and body. In this case nearly the same conditions were presented in both limbs. On the left side there was an oblique fracture, with shortening to the extent of about two inches; the upper fragment was tilted forwards and rather inwards, the lower one being drawn up behind it to the extent indicated. On dividing the psoas and iliacus, the upper fragment could be depressed slightly. The adductor brevis and pectineus were now seen to be tense; on cutting them through, it could be still further depressed. It was now drawn strongly inwards, in consequence of the extreme tension of the internal rotator muscles; on cutting them through, the fragment yielded completely. Part of the adductor magnus and of the adductor longus was torn. The other muscles were uninjured. When extension was made with the limb straight out, the flexors of the leg offered a slight resistance: they were divided. The vastus externus was next cut through; the lower fragment could then be drawn down a quarter of an inch; on dividing the vastus internus and crureus, it yielded one inch more; on cutting through the adductor magnus and longus, it came down three quarters of an inch more; thus making up the two inches of shortening. On the right side, the fracture was the same as that in the other limb. The effect of the section of the different muscles was the same; but the vastus externus seemed to take a somewhat larger share in the displacement of the lower fragment.

The *Treatment* of fractures of the shaft of the thigh-bone may be conducted in different ways, each of which presents advantages in particular cases; hence an exclusive plan of treatment should not be followed.

Whatever treatment is adopted, and however carefully it may be carried out, the Surgeon must not be disappointed if, in the adult, a certain amount of shortening be left. This is more particularly the case where the fracture is oblique and high up: the more transverse and the nearer the condyles, on the other hand, the less will be the liability to shortening. In children, union may almost always be procured without any shortening of the bone. But a slight

diminution in the length of the limb is in reality of no consequence, and gives rise to no inequality of gait ; the pelvis, by the obliquity it assumes, remedying this. It is only when the shortening exceeds half or three quarters of an inch, that it is important and occasions deformity. The rotation outwards of the lower fragment, however, if not corrected by treatment, seriously cripples the patient, as it leaves the toes and the patella directed outwards, so that the movements of both the knee and the ankle are rendered useless in walking.

1. The fracture may be treated by simply relaxing the muscles of the limb. This is effected by laying it upon its outer side, flexing the thigh to nearly a right angle with the body, and the leg upon the thigh, and supporting the limb in this position by an angular wooden or leather splint, extending from the hip to the knee or outer ankle, and by a short inside thigh splint. This position I have occasionally adopted in fractures about a couple of inches below the trochanters, in which there is a great tendency to the projection outwards of the lower end of the upper fragment, and have found these cases turn out better in this way than on any other plan of treatment.

2. Extension, without regard to muscular relaxation, by means of Liston's

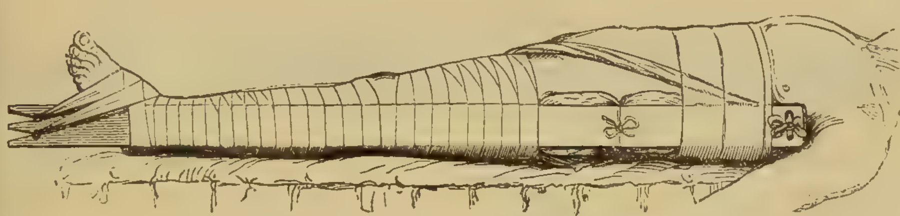


Fig. 232.—Liston's Long Splint.

or Desault's long splint and perineal band (Fig. 232), will be found a most successful plan of treating fractures in the middle and lower parts of the thigh.

In employing the long splint for the treatment of these fractures, care must

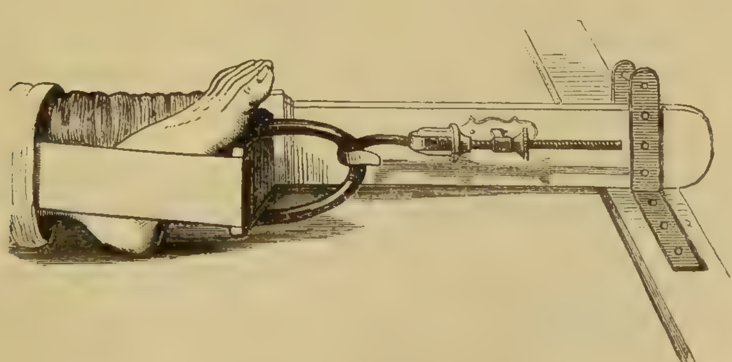


Fig. 233.—Browne's Elastic Catch.

be taken that it be of sufficient length to extend about six inches below the sole, and nearly as high as the axilla. The perineal band should consist of a soft handkerchief covered with oiled silk, and must be gradually tightened. A very ingenious appliance has been contrived by my former House-Surgeon,

Mr. G. Buckstone Browne, for employing elastic extension from the foot. It consists of a brass catch, such as are used for the strings of window-blinds, attached to a vulcanized rubber ring, which is connected with a transverse piece of wood fixed to the leg by adhesive straps (Fig. 233). By means of this contrivance, elastic traction can be kept up to any degree required, without the danger of galling the skin of the instep. If the perineal band occasion excoriation or undue pressure, so as to necessitate its removal, I have found advantage from keeping up extension with a heavy weight attached to the leg by plaster, counter-extension being made by the weight of the patient's body, the foot of the bed being slightly elevated on a couple of blocks of wood.

Another useful form of the long splint is the following: extension is made by a carefully padded handkerchief, the middle of which is placed above the heel behind, and the two ends are then brought forward and crossed over the instep and afterwards passed through the notches at the end of the long splint and securely tied; counter-extension is made by a perineal band; four short

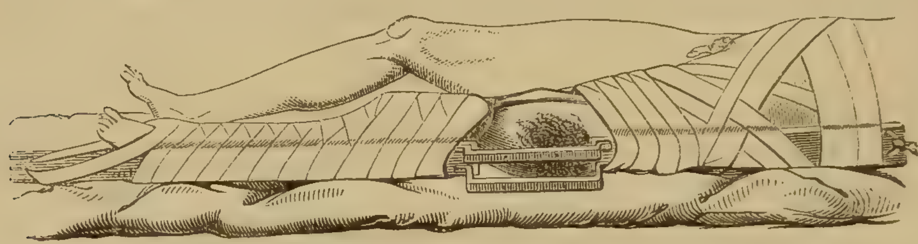


Fig. 234.—Compound Fracture of Shaft of Thigh-bone: Treatment by Bracketed Long Splint.

splints are secured by straps and buckles round the thigh, the anterior reaching from the groin to the patella, the posterior from the folds of the nates to the upper part of the ham, the inner from the perinæum to just above the prominence of the inner condyle, and the outer from just below the trochanter to above the outer condyle. A small sheet, folded till it reaches from the groin to the malleoli, is to be wrapped round the long splint so as to get a firm hold of it, and then brought round the thigh, passing under it, and secured by strong pins to the part of the sheet round the splint. A body bandage about eighteen inches wide is then applied in the same way. In this apparatus the long splint is used merely for extension and to fix the hip- and knee-joints, the four short splints holding the bone in position.

In all forms of the apparatus care must be taken that the splint is wide enough, otherwise rotation outwards may take place. This is further prevented by the apparatus represented in Fig. 233. This consists of a thick piece of board upon which are screwed two rectangular pieces of iron between which the splint is placed. This serves not only the purpose of preventing eversion, but it tends to raise the heel from the bed, and thus to prevent the pain often caused by its pressing on the bed-clothes.

In cases of compound fracture, where the wound exists in the posterior and outer part of the limb, I have found a long thigh-splint, made of oak and bracketed opposite the seat of injury, the most convenient apparatus, enabling the limb to be kept of a proper length, and the wound to be dressed at the same time (Fig. 234).

3. The double-inclined plane is especially useful in many compound fractures of the thigh, often affording greater facilities for dressing the wound and the general management of the case, than any other apparatus that can be applied.

4. Extension of the limb by the attachment of a weight to the foot, a plan of treatment employed by James, of Exeter, and perfected by Buck, of New York, is a most simple and efficient means of treatment. The accompanying drawing (Fig. 235) illustrates this well. The weight required for extension should vary in the adult from five to ten pounds. The counter-extending

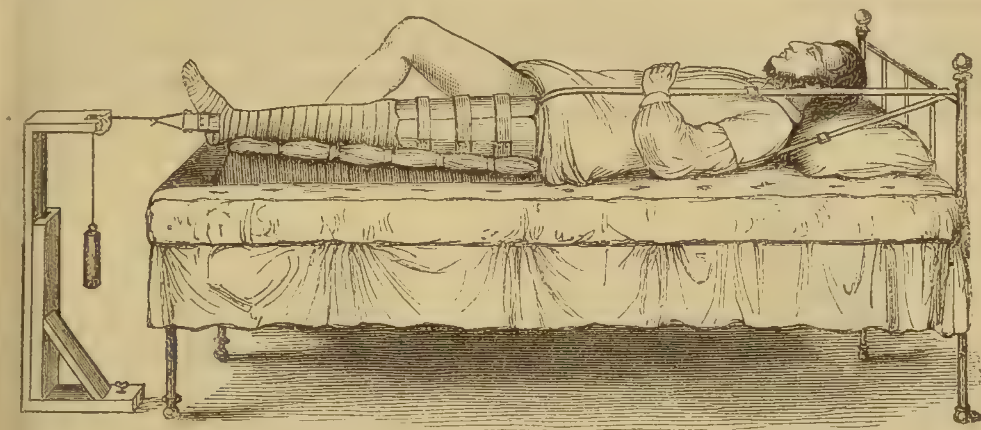


Fig. 235.—Fracture of Shaft of Thigh-bone: Treatment by Weights and Short Splints.

means consist of a perineal band, which should be of India-rubber tubing properly covered with muslin and fastened to the head of the bedstead by means of straps.

5. Suspension of the limb from a splint applied along the anterior aspect, as in Fig. 236, has been recommended by N. R. Smith, of Baltimore. As a general

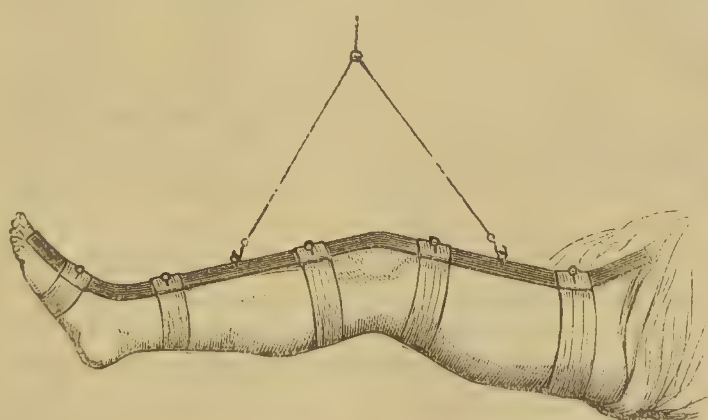


Fig. 236.—Limb suspended from Splint by Slings, preparatory to application of Roller.

plan of treatment, it is not likely to be found advantageous. But it is easy to understand that, in certain cases, where injury has been done to the soft parts of the limb posteriorly, it might be found very useful.

6. Thomas's knee-splint applied as for disease of the joint (*vide* Disease of

Knee, Vol. ii.), with four short splints surrounding the broken bone, forms a most excellent apparatus for a fracture of the femur. The end of the splint must be slung to a cradle by a loop of bandage so as to raise it about six inches from the bed (Fig. 237).

7. The starched or plaster-bandage may be employed in most cases. In treating fractures of the shaft of the thigh-bone with the starched bandage, the following plan will be found convenient. The limb should be evenly and thickly enveloped in a layer of cotton wadding ; a long piece of strong pasteboard, about four inches wide, soaked in starch, must next be applied to the posterior part of the limb, from the nates to the heel. If the patient be very muscular, and the thigh large, this must be strengthened, especially at its upper part, by having slips of bandage pasted upon it. Two narrower slips of pasteboard are now placed, one along each side of the limb, from the hip to the ankle, and another shorter piece on the fore part of the thigh. A double layer of starched

Fig. 237.—Thomas's Knee' Splint applied for a Fracture of the Femur.

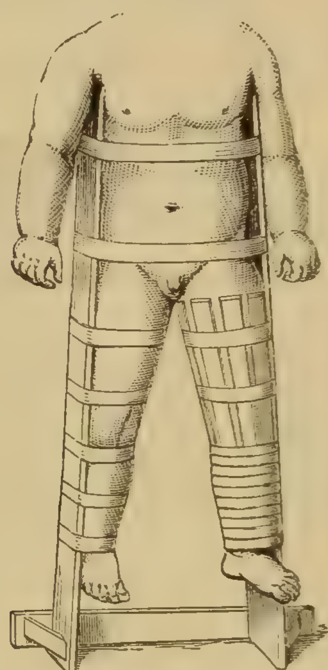


Fig. 238. — Hamilton's Double Thigh Splint with Cross Bar.

bandage should now be applied over the whole, with a strong and well-starched spica. It should be cut up and trimmed on the second or third day, and then re-applied in the usual way. With such an apparatus as this I have treated many fractured thighs, both in adults and in children, without confinement to bed for more than three or four days, and with little if any shortening or deformity being left (Fig. 179). The points to be especially attended to are, that the hinder pasteboard-splint be very strong, at the upper part especially, and that the spica be well and firmly applied, so that the hip and the whole of the pelvis may be immovably fixed.

A *simple comminuted* fracture of the thigh-bone is usually best treated on the double inclined plane for the first three weeks, after which it may be put up in the starched bandage.

In fractures of the femur in children, it is often difficult to maintain good position, owing to the extreme restlessness of the patient. In such cases Hamilton recommends that a long splint be applied to the sound thigh as well as to the broken one. The two splints are connected together at the bottom by a transverse bar (Fig. 238), and some short splints must be put round the thigh to fix the broken bone. I can speak from experience of the very great advantages of this method in young children. The child can be taken up and turned over with the splint without disturbing the fracture in the slightest degree.

Another excellent plan is that, recommended by Bryant, of applying a back-splint from the heel to the nates and short splints on the sides and front of the thigh, strapping having been previously fixed to the leg, by means of which extension can be made. The limb is then slung up to a hook in the ceiling or to any other convenient point, so as to keep it at right angles to the body. By this means the bandages are kept out of the way of the evacuations passed into the bed, and the weight of the body acts as a constant counter-extending force.

In very young children, plaster-of-Paris and starched bandages can hardly be used, as it is quite impossible to keep them clean.

The Treatment of Compound and Comminuted Fracture of the Thigh-bone will vary according as the injury arises from gun-shot, or is an accident of civil life. In the former case, for reasons stated at p. 342, amputation should at once be performed if the fracture be below the upper third of the bone. When the upper third is splintered, the result of amputation is so very unsatisfactory, that the patient may have a better prospect of recovery if the limb be treated in splints, and an endeavour made to save it, disarticulation at the hip-joint in such cases being almost invariably fatal.

When a compound fracture of the thigh-bone occurs from one of the common accidents of civil life, even if it be comminuted, the line of practice is not so defined. The course that the Surgeon adopts must be influenced by the extent of injury done to the soft parts, more particularly to the main blood-vessels of the limb. If the integuments and muscles be extensively torn and lacerated, or if there be reason to believe that the femoral vessels have suffered, amputation must be practised. But if the wound be but small, made by the perforation of the bone rather than by the violence which occasioned the fracture, and if the vessels be uninjured, an attempt must be made to save the limb, which should be put up on the double inclined plane or in the long bracketed splint, and treated with the strictest attention to drainage and to the prevention of decomposition.

The treatment of the complication of a *wound of the main artery*, femoral or popliteal, with and by a fracture of the thigh-bone, will vary according as the injury is compound or simple. Such an accident, complicating a compound fracture, would probably be a case for immediate amputation. If the fracture be simple, and a diffused traumatic aneurism form in the ham or lower part of the thigh, we must, in accordance with the principles laid down at page 463, ligature the superficial femoral artery; unless gangrene be supervening, or have actually supervened, when the thigh must be amputated above the fracture.

In discussing the treatment of these accidents, in which the question of amputation of the thigh is raised, I cannot too strongly state my conviction

that, unavoidable as it undoubtedly is in some cases, as the only alternative left to the Surgeon, this operation, when practised primarily *for compound fractures of the thigh-bone*, is one of the most fatal in surgery, and should accordingly not be too hastily resolved upon.

3. Fractures in the Vicinity of the Knee-joint.—The lower end of the thigh-bone may be broken across transversely, immediately above the condyles, and occasionally this may be complicated by a vertical fissure separating the condyles from each other, and extending into the knee-joint. In other cases, the fracture extends through one of the condyles, detaching it from the shaft of the bone. The readiness with which crepitus can be felt, the line of fracture made out, and the displacement removed by lateral pressure, determines at once the nature of this accident.

When the femur is fractured transversely immediately above the condyles, the lower fragment is powerfully acted on by the gastrocnemius, plantaris, and popliteus muscles, which flex it upon the tibia, causing its upper extremity to project backwards into the ham, while the lower end of the upper fragment rests on its anterior surface. Thus, although the limb may be apparently extended, the knee-joint is in reality flexed. If a limb in this condition were put up on a long splint and extension made, the displacement would be increased, and non-union of the fracture would very likely result; or, if union did occur, the utility of the limb would be most seriously impaired. By putting the limb on a double inclined plane in a flexed condition the deformity is at once removed, the fractured ends of the bones coming into perfect apposition. Bryant has recommended in these cases to divide the tendo Achillis, and in case the double inclined plane failed to overcome the deformity, this might be of use.

Fig. 239. — Impacted Fracture of Lower End of Thigh-bone.

Fracture of the lower end of the thigh-bone, communicating with open wound of the knee-joint, is usually a case for amputation.

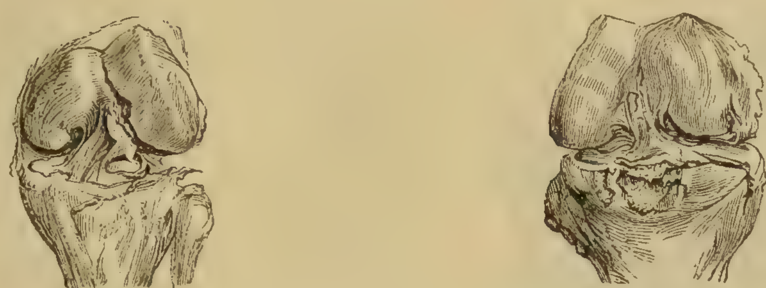
Impacted Fracture of the Lower End of the Femur.—In these cases the shaft is always driven into the lower fragment. I have had several such cases under my care. In one, the upper fragment, which was very oblique, was firmly driven into the cancellous structure of the lower one (Fig. 239). In another case, the condyles of both thigh-bones were splintered into a number of fragments, amongst which the shafts were impacted. Excellent union, however, took place, the skin having been uninjured. The diagnosis is not always easy, as unnatural mobility and crepitus may both be wanting; and in many cases, either from a fissure extending downwards or from the bruising at the time of the accident, effusion occurs into the knee-joint, which still further conceals the nature of the injury. The most characteristic feature in these cases is the shortening, and later on, as the swelling subsides, the deformity at the seat of fracture may be clearly recognized.

Separation of the Lower Epiphysis of the Femur is not an uncommon accident in children. The wide surfaces are seldom completely separated, and the nature of the injury is further obscured by effusion into the joint; but it

can usually be recognized by seizing the shaft of the femur in one hand and the knee in the other, when lateral movement will be recognized, accompanied by the soft crepitus characteristic of a separated epiphysis. The treatment consists simply in supporting the limb for a few days on a back splint, till the swelling has subsided, when a starched bandage or plaster-of-Paris splint may be applied. Union usually takes place by bone, and is followed by some shortening from interference with growth.

The **Period of Union of Fractures of the Shaft and Lower end of the Femur** is between seven and eight weeks in the adult, at the end of which time the patient may dispense with artificial support. It is, however, always about three months before full use of the limb is regained. In children under ten, union is usually firm at the end of the fifth week.

Fractures in the Knee-joint.—It occasionally happens that a small fragment of one of the condyles of the femur may be chipped off by a violent blow, and become loose in the cavity of the joint. After the inflammation and effusion into the joint, consequent on the accident, have subsided, the fragment may be recognized as a loose body in the joint. (See Diseases of Joints : Loose Bodies.)



Figs. 240, 241.—Fracture of Condyles from fall on the Bent Knees.

In violent blows on the upper part of the tibia, or in forcible and extreme flexion of the knee, it sometimes happens that the bony attachment of one of the crucial ligaments is torn up. In the case from which Figs. 240 and 241 were taken, the patient fell from a great height on the bent knees. In one knee, the anterior crucial ligament had torn up a piece of the tibia, to which it was attached. In the other, the posterior crucial ligament had torn out a piece of the femur, and the bone was fissured a long way up between the condyles. In the case from which Fig. 242 was taken, the anterior crucial ligament was torn from its attachment, bringing with it a scale of bone from the tibia. These cases cannot be diagnosed during life. The treatment would be that of a sprain of the knee, with effusion of blood into the joint.

Fracture of the Patella may be the result of direct violence, when the bone is often comminuted, or even broken longitudinally, being split, and the joint injured. But most frequently it occurs as the consequence of the sudden and violent action of the extensor muscles of the thigh, in the attempt a person makes to save himself from falling when he suddenly slips backwards. The knee being semi-flexed, the patella rests on it only in its transverse axis, and is readily snapped across, much in the same way as one breaks a stick across some resisting object. All fractures of the patella from

muscular action are transverse (Fig. 243). The patient does not break his patella in these cases by falling upon it, but he falls because the patella has been broken by the violent and almost spasmodic action of the extensors of the thigh in his efforts to save himself. In consequence of these fractures being occasioned by muscular action, they are more frequent in men, especially about the middle period of life, less common in women, and extremely rare in children. I have once, however, had under my care a child under ten years of age, who had a transverse fracture of the patella. It not unfrequently happens when one patella has been fractured, that the unsteadiness of gait causes the opposite one to be broken by muscular action in an effort to avoid a fall. The same patella may be broken more than once; in the cases that I

Fig. 242.—Tibial Attachment of Anterior Crucial Ligament torn up.

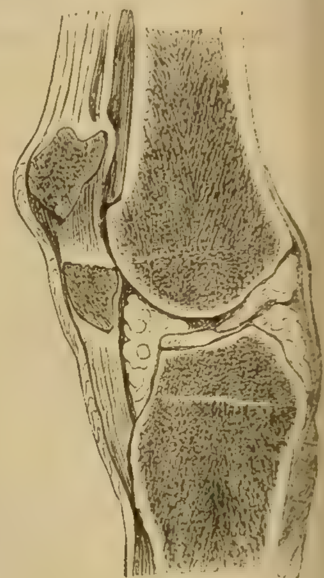


Fig. 243.—Diagram of position of fragments in Fracture of Patella. Eversion of Upper Fragment.

have seen, the second fracture has always occurred in the upper fragment, a little above the line of the original fracture.

The *Signs* of this fracture are very evident. When it is transverse, and has been produced by muscular action, the fibrous expansion over the bone is torn; and the separation between the fragments (Figs. 243, 244), which is much increased by bending the knee (Fig. 245), and the inability to stand or to raise the injured limb, indicate what has happened. When it has been produced by direct violence, the muscles being at rest, there is little or no separation, even though the fracture be transverse. In such cases, and when it is longitudinal or comminuted, the crepitus and mobility of the fragments point it out. Immediately on the occurrence of a transverse fracture of the patella, the knee-joint swells up owing to the effusion of blood into the synovial membrane. This swelling subsides after a few days' rest.

Mode of Union.—When the bone is broken transversely, it very rarely indeed unites by osseous matter, in consequence of the wide separation of the fragments; there are, however, two or three cases on record in which this kind of union has taken place in these fractures. In the longitudinal and comminuted fractures, osseous union readily occurs, the fragments remaining in close

apposition. In the majority of cases of transverse fracture, the fragments remain separated by an interval varying from one-fourth of an inch to an inch ; but in some instances the gap is much greater, amounting even to four or five inches. When the separation does not exceed an inch and a half, the gap is usually filled up by ligamentous tissue, uniting the fragments firmly. In some of the cases, however, in which the separation between the fragments does not exceed this distance, and in most of those in which it extends beyond it, W. Adams has found that the fracture is not united by any newly-formed fibrous tissue, but that the fragments are bound together simply by the thickened fascia which passes over the patella, with which is incorporated the bursa patellæ. Adams finds that the aponeurotic structure thus uniting the fragments may be arranged in different ways. Thus it may be adherent to the anterior periosteal surface of both fragments ; or the connecting aponeurosis may be reflected over, and be adherent to, both the fractured surfaces ; or, lastly, (and this is the most frequent arrangement,) the connecting aponeurosis may pass from the periosteal surface of the upper fragment to the fractured surface of the lower one, to which it becomes closely and firmly united. In the majority of cases, when united by aponeurotic tissue, the fragments gape somewhat towards the skin, coming into better contact posteriorly. Thus it would appear that a patella fractured transversely may unite in two ways ; most frequently by the intervention of thickened aponeurotic structure, and next, by a ligamentous or fibrous band. Of 31 specimens in the London museums, examined by Adams, it was found that in 15 aponeurotic union had taken place, in 12 ligamentous union, and in the remaining 4 the kind of union could not be determined.

Fig. 244.—Fractured Patella: Side view of Limb, straight.

Fig. 245.—Fracture of Patella: Separation between Fragments increased by bending the Knee.

The aponeurotic union always leaves a weakened limb and an unprotected joint ; for, in consequence of the separation of the fragments, and the folding in of the fascia, the fingers can be thrust in between the articular surfaces of the knee.

Treatment.—In many cases of fractured patella, there is rather severe inflammation of the knee, with great synovial effusion. This requires to be reduced by rest and the application of evaporating lotions, before any other treatment can be adopted. If the effusion be very abundant, the treatment may be hastened by removing it with an aspirator. If the instrument be thoroughly washed with carbolic acid lotion (1 in 20) before being used, there is no danger in the operation. When the fluid has been removed or absorbed, means must be taken for the union of the fragments ; with this view, the principal point to be attended to is, to keep them in sufficiently close apposition for firm ligamentous union to take place. The upper fragment, which is movable, and has been retracted by the extensor muscles of the thigh,

must be drawn down so as to be approximated to the lower one, which is fixed by the ligamentum patellæ. This approximation of the fragments may be effected either by position and relaxation of the muscles, or by mechanical contrivance. Simple position usually suffices for this purpose, and must be attended to whatever mechanical appliances are used. By placing the patient in a semi-recumbent position, and elevating the leg considerably, so as to relax the muscles of the thigh completely, the upper fragment may be brought down to the lower one, and, if necessary, may be retained there, after any local inflammation that results from the accident has been subdued, by moulding a gutta-percha cap accurately to and fixing it firmly upon the knee, or by the application of pads of lint and broad straps of plaster. These straps of plaster may be

Fig. 246.—Stellate Fracture of the Patella.

Fig. 247.—Aponeurotic Union of a Fractured Patella: Side-view.

Fig. 248.—Fracture of Patella, united by ligamentous tissue.

applied above and upon the upper fragment in a diagonal direction from above downwards. They should be of sufficient length to embrace the limb and a back splint, to which they are to be fixed; or a figure-of-8 bandage may be applied round the limb and splint together. This position must be maintained for at least six weeks; at the expiration of which time the patient may be allowed to walk about, wearing, however, an elastic knee-cap, or, what is better, a straight leather-splint in the ham, so as to prevent the knee from being bent for at least three months. If this precaution be not taken, the union between the fragments, which at first appeared to be in very close contact, will gradually lengthen, until in the course of a few months an interval of several inches may be found between them. In these cases, however, even though the separation between the fragments be great, it is remarkable how well the limb may be used, especially on level ground; and with the aid of a knee-cap but little inconvenience is experienced by the patient.

If the occupation of the patient is such that he cannot be kept at rest during the treatment, the starched bandage or plaster-of-Paris-splint will be found very useful, the patient being with it enabled to walk about during the whole of the treatment. The action of the bandage is much increased by drawing down and

fixing the upper fragment by two broad strips of plaster firmly applied above it. A back splint of pasteboard is required to fix the knee, and a good pad of lint with a figure-of-8 bandage should be applied above and below the fracture to keep it in position. In several cases I have obtained very close and firm union between the fragments in this way, without confining the patient to bed after the third day.

Various attempts have at different times been made to bring down and to fix the upper fragment, so as to keep it in contact with the lower one; or, if this be impracticable, to shorten the distance between them, and thus to lessen the length of the bond of union. With this view, an apparatus consisting of two broad bands of leather, buckled above and below the knee, and united by longitudinal straps, which can be shortened at pleasure, is very commonly employed. Malgaigne, with the same view, constructed a pair of double hooks, which, being fixed into the two fragments, were drawn together by a screw; and Eve, of Tennessee, accomplishes the same object by means of a ring passed round the fragments. All these means undoubtedly secure the object for which they are intended, and each may be found an useful adjunct to position in any given case. Malgaigne's hooks are undoubtedly the most effectual; but the great objection to their use consists in the pain and irritation that are often induced by their penetration of the skin.

W. Manning, a former House Surgeon of University College Hospital, has made some very careful dissections of the arterial supply of the patella (Fig. 249). He finds that the vascular arch by which the upper fragment of a broken patella is supplied is situated at the very spot where the greatest amount of pressure is usually applied, and that not unfrequently the internal superior and inferior articular arteries arise from a common trunk, which must inevitably be compressed against the internal condyle of the femur, so that both fragments may thus be starved of blood; and that this want of proper blood-supply has an additional tendency to prevent firm union. As an additional evidence of the compression of the nutrient arteries of the patella by the ordinary apparatus, I may mention that Manning has found, on injecting a limb thus put up, that all the arteries were filled except those supplying the patella. In addition to this, Manning is of opinion that, in the ordinary treatment of fractured patella, the apparatus in use does not retain the fragments sufficiently long in position, or control the muscles efficiently.

Fig. 249.—Arterial Supply of Patella (Manning).

With the view of remedying these inconveniences, Manning has constructed the splint (Fig. 250), of which the following is a description. It consists of a wooden back-piece, a little wider than the knee-joint, and long enough to reach from the sole of the foot to the gluteal fold, and provided at the lower end with a foot-piece, A. At the junction of the middle and lower thirds is a transverse oblique slit, B, one and a half inches long. Strips of strong plaster, two inches broad, and long enough to encircle the thigh and overlap by some inches, are attached

to a calico band, C. The free end of this band is carried through the slit, and the straps of plaster are open on the upper part of the splint. A piece of wood, E, is attached to the lower part of the splint, and another piece of corresponding size is attached to a loop at the end of the calico band, so that, when drawn down and the splint adjusted, these three pieces may be five or six inches apart.

The foot and leg having been previously bandaged as far as the lower edge of the patella, and the splint padded so as to leave the slit uncovered, the

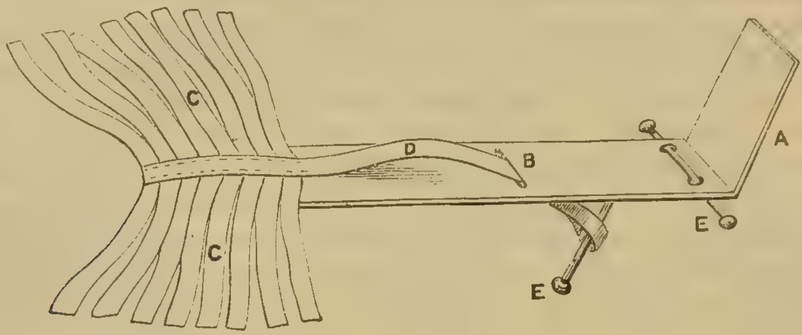


Fig. 250.—Manning's Splint for Fractured Patella.

strapping is heated by means of a bottle of hot-water (which is more convenient than a strapping-tin), and while an assistant draws down the upper fragment by grasping the muscles of the thigh, the straps of plaster are carried firmly round the limb from above downwards, extending from just below the gluteal fold to within three inches of the upper border of the patella. It being important that the band of calico should be kept in the middle line behind, the upper part of the thigh is then secured to the splint by a few turns of a roller. Lastly, as many elastic rings (those known as "office-bands"

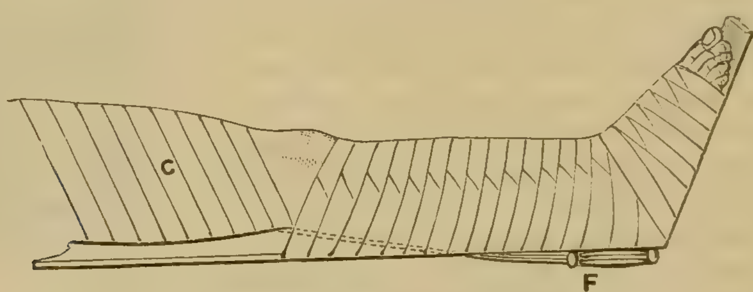


Fig. 251.—Manning's Splint applied.

answer the purpose very well) as will serve to approximate the fragments without causing too much pain to the patient, are passed over the projecting ends of the pieces of wood, as at F, Fig. 251, on each side of the splint, so as to exercise sufficient traction on the muscles pulling on the upper fragment.

H. O. Thomas has recently published a paper on fractured patella, in which he maintains that the chief points to be attended to are, first, to keep up the treatment for a sufficient length of time; secondly, to avoid interference with the circulation around the patella; thirdly, that no strain in the direction of flexion be allowed during treatment; and, lastly, "that the temporary ankylosis produced by the treatment should be allowed to pass away spontaneously." The method of treatment he recommends (Fig. 252) is the following. A Thomas's

bed knee-splint (see Diseases of the Knee-Joint), which need not accurately fit the patient, provided it be of sufficient length, should be at once applied. The leg is to be retained in position by the usual extension apparatus of adhesive plaster, the ends of the strips being fixed round the end of the splint. "To the bandages which secure the extension-plaster round the leg is sewn a piece of elastic webbing with adhesive material spread upon half its length; this being thus fixed below is stretched over the fractured patella and attached by adhesion to the skin of the thigh above the upper fragment of the patella, which it thus constantly draws gently down and exercises also very slight surface pressure over both fragments, pressing them into the space between the condyles of the femur and head of the tibia." The bandages are now applied over the thigh and leg, and a support arranged, either of leather or adhesive plaster, behind the popliteal space, sufficiently tight to hinder any backward strain on the knee-joint. As soon as it can be made, a walking "caliper" knee-splint with a boot must be fitted to the patient; after which he can leave his bed and move about during the remainder of the treatment. Thomas recommends that the treatment should be continued uninterruptedly for nine months at least.

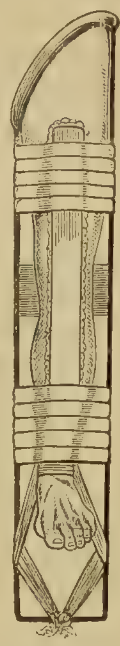


Fig. 252. — Thomas's Knee - splint, applied for Fractured Patella.

In order to bring the two fragments of a transverse fracture of the patella into accurate apposition, it has been recommended to make a longitudinal incision in the front of the knee of sufficient length fully to expose the broken bone, and to drill its fragments obliquely, taking care not to reach the cartilaginous surface in so doing, and then to unite them by a strong wire suture. By this operation, the knee is necessarily opened, and the patient is exposed to the dangers of a wounded joint. This operation seems to have been performed many years ago by Cooper, of San Francisco. In this country it was first suggested by Lister as being free from danger, provided strict antiseptic treatment was adopted. It was first performed by Cameron, of Glasgow, and subsequently by Lister, Henry Smith, Royes Bell, and many other Surgeons. Lister recommends that the wire should be cut short, and the ends hammered down, the wound being allowed to heal over it. Passive motion is to be commenced at the end of the second week. It is essential that good drainage should be provided from the joint during the first few days. This is best done by a small incision at the most dependent part of the outer side of the joint, through which a drain of horse-hair or an india-rubber tube may be inserted. The operation has been performed now a considerable number of times; and all recorded have so far been successful, good bony union having been obtained in most cases. It has been done both in recent fractures and in old cases in which the union was so bad that the limb was practically useless. In spite of this success, however, when the serious consequences that would inevitably follow if septic inflammation were accidentally set up in the joint, and the excellent results that are obtained as a rule by simple modes of treatment are taken into consideration, it is evident that the operation is adapted only to exceptional cases, in which either other modes of treatment have failed, or the importance of a firm knee is so great to the patient as to justify him in running the extra risk involved in the operation.

Stiffness of the knee often remains to a very inconvenient degree after the treatment of a fractured patella. It is usually remedied by friction and manipulation. Thomas asserts that it is better left entirely to nature, and states that he has seen it take two years before useful mobility returned. But should it not yield to these minor means, an apparatus consisting of a thigh-and-leg piece of stiff leather, united by angularly hinged lateral iron rods, and having an india-rubber "accumulator" adapted behind, should be worn. The continued traction of the "accumulator" will gradually flex the knee. But, as the knee becomes bent, the close union that may have appeared to exist between the fragments gradually yields, and they often gape more or less widely, much to the disappointment of both Surgeon and patient, the ligamentous band stretching like a piece of vulcanized india-rubber. This cannot be helped; there is the alternative between a straight and stiff knee with close union, or a flexible and mobile one with gaping of the fragments. After the knee is flexible, lateral hinged splints may be worn without the elastic strap. The limb on recovery is usually perfectly strong, and good for any exercise except jumping.

In **Simple Comminuted Fractures of the Patella**, the result of direct blows or kicks, the fragments are not much separated, and union takes place readily by bone. In these cases, after the inflammation, which usually is rather acute, has subsided, the starched bandage may be applied, and the knee and fragments thus both kept immovable.

Compound and Comminuted Fractures of the Patella, especially if occasioned by bullet-wounds, and opening the knee-joint, are always most serious injuries. Under strict antiseptic treatment, however, they can usually be saved. The wound should, if necessary, be enlarged, and any loose fragments of bone removed; the cavity of the joint should then be syringed out with carbolic-acid-lotion, or some other efficient antiseptic solution. A drainage-tube must then be inserted on the outer side of the joint. This is best done by passing from the wound a pair of sinus forceps, or the finger, if the opening is large enough, and making it project at the lowest possible point on the outer side of the joint; it may then be cut down upon and the tube passed. The wound must be dressed with some efficient form of antiseptic dressing and absolute rest maintained. A case of this kind in University College Hospital, which was complicated by a fracture of the thigh about the middle on the same side, progressed under carbolic-gauze-dressing exactly like a simple fracture. It was caused by a fall of about thirty feet, the patient coming down upon the bent knee. In the absence of the means of efficiently carrying out this treatment, as must sometimes necessarily be the case in military practice, immediate amputation would be the safest treatment to adopt.

Necrosis of the Patella as the result of fracture is rare. In one such case which was under my care at the Hospital, the patient, a middle-aged man, had met with an ordinary transverse fracture of the patella, which united by ligament; two years after the accident, and without any fresh injury, he came to the Hospital, with necrosis of the outer half of the upper fragment, which was completely detached, and lying in a cavity shut off from the joint. I cut down upon and removed the necrosed fragment, which appeared to constitute about one quarter of the patella. No cause could be assigned for the necrosis, except defective vascular supply to this part of the bone.

Fractures of the Bones of the Leg.—The bones of the leg are frequently broken, the fracture of the fibula being, as a rule, at a higher level than that of the tibia. When both bones are broken, the fracture is generally situated near the junction of the middle and lower thirds, and the lower fragments are, in the majority of cases, drawn upwards, behind the upper, by the action of the gastrocnemius muscle ; so that the edge of the upper fragment of the tibia projects under the skin and may perforate it. In some instances, however, the direction of the fracture is such that the lower fragments ride over the front of the upper. The tibia, though a stronger bone than the fibula, is more frequently fractured, owing to its being less protected from blows by muscles, and receiving more directly all shocks communicated to the heel. The fractures of the upper part of this bone are usually transverse, and result from direct violence ; those of the lower part are oblique, and proceed from indirect violence. When both bones are broken, the usual signs of fracture, such as shortening, increased mobility at the seat of injury, and crepitus, render the diagnosis easy ; but when one bone alone is broken, it is not always a very simple matter to determine the existence of the fracture ; the sound bone, acting as a splint, prevents displacement, and keeps the limb of a proper length and steady. If it be the tibia alone that has been broken, the fracture may be detected by running the finger along the subcutaneous edge, until it comes to a point that is somewhat irregular, puffy, or tender, where by accurate examination some mobility and slight crepitus may be detected. When the fibula alone is broken, the thick layer of the peroneal muscles, overlying its upper two-thirds, renders the detection of the fracture difficult. It can usually be detected by pressing the fibula firmly towards the tibia, when the patient will complain of pain at the seat of fracture, and at the same time a click of crepitus may be felt now and then ; by shifting the point of pressure, it will be ascertained that the pain is always at the same spot. In the lower third, the fracture is easily recognized by attention to the same signs that occur in fractured tibia.

In the **Treatment of Simple Uncomplicated Fractures of the Leg**, every possible kind of apparatus has been used. In the majority of cases where there is but little displacement and swelling, ordinary leg-splints (Cline's, well padded, are extremely convenient), are readily applied and keep the bones in good apposition. These may be kept on for the first few days till all swelling has abated, and then replaced by the starched or plaster bandages. In fracture of the leg, indeed, the starched bandage or the Bavarian or Croft's splint is especially applicable. The starched bandage should be applied as follows. The limb having been well covered with wadding, a strong soaked pasteboard splint, four inches broad, and long enough to extend from above the knee to six or eight inches beyond the heel, should be applied to the back of the leg. The projecting terminal piece is now to be turned up along the sole of the foot, and two lateral strips adapted, one to each side of the limb. Over this the starched bandage, single or double according to the size of the limb, must be tightly applied. After it is dry, about the end of the second day, it must be cut up as represented in Fig. 177, and re-adjusted, and the patient may then walk on crutches with perfect safety. M'Intyre's splint (Fig. 253) will be found of great service in the earlier periods, if there be much ecchymosis or extravasation, as it keeps the limb in an easy position, and allows the ready application of evaporating lotions. In applying this

splint, there are four points that require to be attended to: 1. That the angle be convenient, and suitable to the apposition of the fragments; 2. That the aperture corresponding to the heel be closed by a few turns of a roller in which the heel may rest firmly, but with a certain amount of yielding pressure;

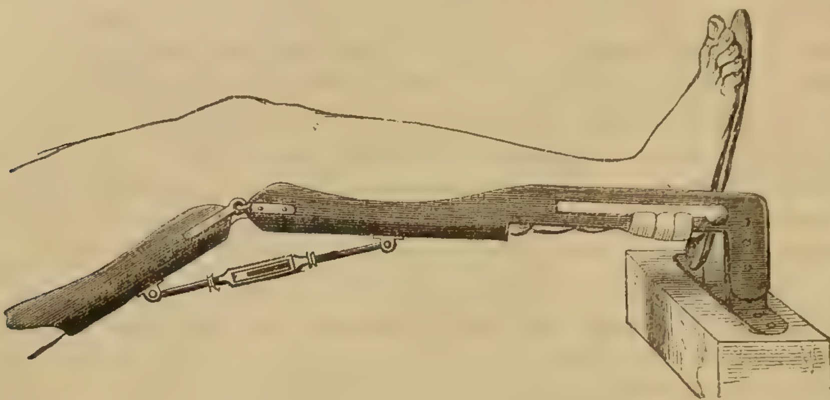


Fig. 253.—M'Intyre's Splint, modified by Liston.

3. That the foot be covered with a flannel sock, from the heel of which a tape passes, by which the foot can be slung up to the foot piece; and, 4. That the lower end of the splint be raised and steadied on a wooden block. In some cases of fracture of the bones of the leg, however, M'Intyre's apparatus

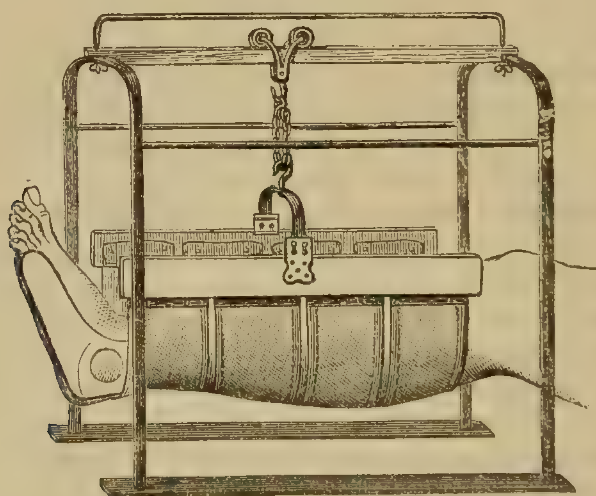


Fig. 254.—Salter's Swing-cradle for Fractured Leg.

is not applicable. This is more particularly the case when the fracture is very oblique, from above downwards, and from before backwards; in these circumstances, the fragments cannot be brought into good position so long as the limb is kept extended and resting on its posterior surface: the bones riding considerably, and one or other of the fractured ends often pressing upon the skin in such a way as to threaten ulceration. In these cases it is, that division of the tendo Achillis has been recommended, with a view of removing the influence of muscular contraction. This appears to me, however, to be an unnecessarily severe procedure, and certainly was not very successful in some

cases in which I have practised it: for although the tendon was exceedingly tense, only temporary benefit resulted, the displacement returning under the influence of the other muscles inserted into the foot. In these cases the bones may usually be brought into excellent position by flexing the thigh well upon the abdomen, and the leg upon the thigh, so that the heel nearly touches the nates, and then laying the limb on its outer side on a wooden leg-splint, provided with a proper foot-piece, and keeping it fixed in this position. In some cases the swing-cradle (Fig. 254) will be found a useful and very easy apparatus. In some fractures of the leg in the upper third, the lower end of the upper fragment projects considerably, and cannot be brought into proper position so long as the knee is kept bent; but if it be extended, so as to relax the extensors of the thigh, the bone is readily brought into good position. In fractures of the leg, as in all injuries of a similar kind, no one plan of treatment should be adopted exclusively, but the means employed should be varied and suited according to the peculiarities of each individual case.

In the management of all fractures of the leg, the foot should be carefully kept as nearly as possible at right angles to the leg. If it be allowed to drop so that the toes point downwards, the stiffness that always follows a fracture of the leg, will fix it in that position for some time after the fracture is united, and until the false position is corrected by forcible flexion, frictions, and rubbing, the patient cannot use his leg for walking, and thus convalescence is very much prolonged.

Period of Union.—The time at which all artificial support may be dispensed with is, when both bones are broken, 8 weeks; if the tibia alone is fractured, 7 weeks; if the fibula alone, 6 weeks.

Complications of Fracture of the Leg.—Should a traumatic aneurism form in the leg, as a consequence of injury of the posterior tibial artery, compression of the superficial femoral in Scarpa's triangle, with pressure by pad and bandage over the pulsating swelling, may succeed. If not, the artery may be ligatured in Scarpa's triangle with good results. Two cases of this kind are recorded, one by Dupuytren, the other by Delpech.

For the treatment of other **Complications of simple Fracture of the Leg**, see p. 525, *et seq.*

Compound Fractures of the Tibia are of more frequent occurrence than similar injuries of any other bone in the body. This is owing to the thin covering of soft parts over the anterior and inner aspect of the bone, and to the fact of its fracture being usually oblique; so that the sharply pointed end of the upper fragment is liable to be thrust through the integument, when the lower part of the limb falls backwards as the injured person attempts to rise or is being raised from the ground. The fracture may, of course, be rendered compound also by the same direct violence that breaks the bone.

The *Treatment* must be carried out according to the principles laid down for the treatment of compound fractures in general (p. 529).

Hæmorrhage is a common complication of compound fractures of the leg. It must be treated according to the rules laid down on p. 533. If the fracture be situated in the lower third, and the artery torn low down in the limb, where the vessels are superficial, and more especially if the injury be near the ankle-joint, an attempt should always be made to apply a ligature to the vessel before proceeding to the extreme measure of amputation.

Fractures in the Vicinity of the Ankle-Joint are among the most common injuries of the bones of the lower extremity. They are usually occasioned by twists of the foot, by slipping off the kerb, by catching it in a hole whilst running, by jumping from a height to the ground, or off a carriage in rapid motion. These fractures are usually associated with severe strain, or even dislocation, of the ankle. Twist of the foot in these cases must not be confounded with dislocation of the ankle. In a twist the foot carries with it the lower fragments of the leg-bones, and the malleolar arch in a more or less perfect state. In a dislocation, the foot is thrown out from under this arch. The twist of the foot is almost invariably outwards, with the inner side downwards and the outer edge turned up, and the sole usually remains in this direction, though not always to the extent that Dupuytren states, and the inner malleolus projects under the skin. Most commonly the toes are turned somewhat outwards, and the heel inwards.

Fig. 255.—Displacement of Bones and Foot in Pott's Fracture (Richard).

Fractures of the lower ends of the tibia and fibula present four distinct varieties in degree.

1. The fibula may be broken at its weakest point, two or three inches above the malleolus externus, the deltoid ligament being either stretched or torn.

2. The fibula may be fractured about three inches above the ankle, the tip of the malleolus internus being splintered off as well (Fig. 255). This constitutes the form of injury called **Pott's Fracture**, and is perhaps the most common fracture in this situation. It very frequently becomes compound, the sharp edge of the root of the malleolus cutting through the skin as the foot is twisted outwards.

3. The fibula may be fractured about three inches above the ankle, and the lower end of the tibia at the same time be splintered off in an oblique direction from without, downwards, and inwards (Fig. 257).

4. The internal malleolus may alone be broken off, the fibula remaining sound, but one of the divisions of the external lateral ligament being torn through.

The *Signs* of these fractures vary somewhat according to the bone that is injured. When the fibula alone is broken, there is but slight displacement of the foot, but great pain and much swelling, with perhaps indistinct crepitus, and irregularity of outline, at the seat of fracture. When the lower part of the fibula is broken, pain is produced at the fractured part by squeezing the bones of the leg together at a point distant from the seat of injury. If the tip of the inner malleolus be broken off as well, this may be ascertained by feeling the depression above the detached fragment. In these cases the crepitus is more distinct, and the displacement of the foot is much more marked, the sole being turned somewhat upwards and outwards, and the patient resting upon its inner side. It is this peculiar twist of the foot with its outer edge turned up, and the inner side down, that constitutes the characteristic sign of Pott's fracture. In those cases in which the lower end of the tibia is

obliquely splintered, as well as the fibula broken, there are not only the ordinary signs of fracture, with eversion of the toes, and a corresponding turning inwards of the heel, but the malleoli are widely separated, giving an appearance of great increase of breadth to the joint; crepitus is very readily felt, and a depression can be perceived corresponding to the line of fracture.

The *Treatment* of these cases is always fraught with difficulty. In consequence of the swelling and inflammation that usually occur, it is often difficult to make out the exact extent and direction of the fracture. This difficulty is greatly increased by the small size and short leverage afforded by

Fig. 256.—Pott's Fracture.

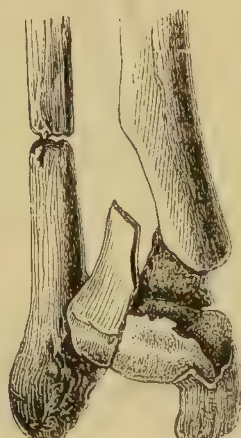


Fig. 257.—Fracture of the Lower End of the Tibia and Fibula.

the fragments; and so great is it, that in some cases it cannot be overcome by any amount of skill and patience that may be brought to bear on the treatment of the injury, but a certain degree of displacement results as the necessary consequence of the injury, leaving a weak and painful joint, the mobility of which is seriously impaired.

If, as usually happens, more particularly when the fracture results from direct violence, there be a good deal of swelling from ecchymosis and inflammatory exudation, this will require to be subdued by the continuous application of cold, and the limb should be laid on a splint. If there be not much displacement of the foot, the treatment may best be conducted by splints with good foot-pieces, and the starched or plaster bandage. When there is no twist of the foot, perhaps the best treatment is to put the limb up in lateral leg-splints, with good foot-pieces, and swung in a cradle. I have found the splint, Fig. 258, a very useful appliance in cases of fracture of the bones of the leg, one or both, in their lower third. The apparatus consists of an ordinary leg-splint cut across at the upper part of the lower third, the two pieces being united by a double rack and pinion. By means of this mechanism four primary movements can be given to the lower part of the splint, by which the various displacements, that are apt to occur in fractures in this situation, can be counteracted and corrected. Thus the lower end of the splint can be moved backwards or

forwards, outwards or inwards (Fig. 258), and by the combined action of the two screws a compound or double movement may be impressed upon the lower fragments of the broken bones. It is in cases of fracture of the lower third of the fibula, with displacement outwards, or of both bones low down with

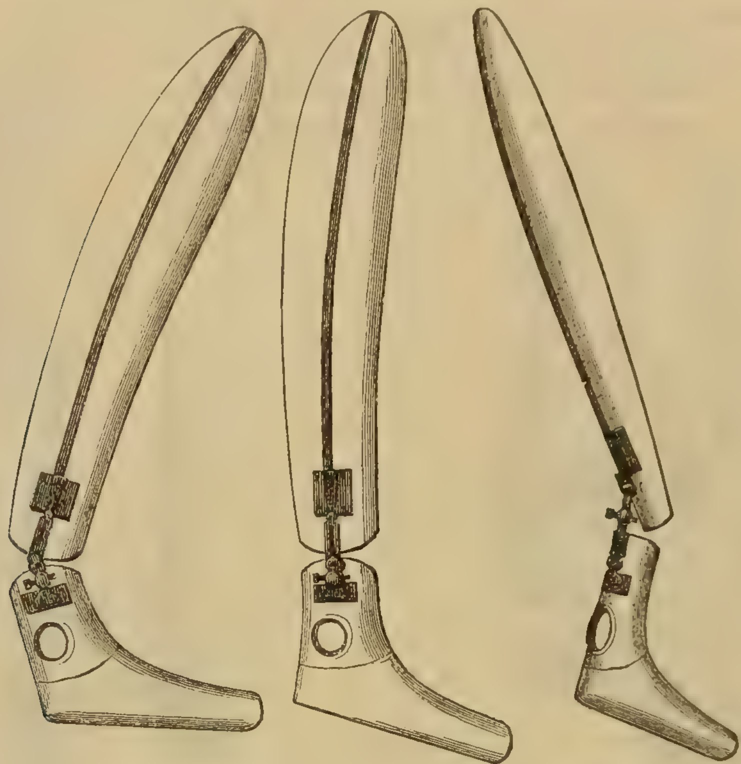


Fig. 258.—Rack-and-Pinion-Splint for Fracture of Lower Third of Leg.

tendency to displacement backwards, that this splint will be found most useful. It may be applied to either side of the leg, as best seems to suit the case in question. Whatever apparatus is used, care must be taken to keep the sole of the foot nearly at a right angle with the leg. If the toes be allowed to

Fig. 259.—Rack-and-Pinion-Leg-splint applied to correct Displacement of Foot outwards.

point, it will be found that there is in some cases a tendency for the astragalus to roll forwards, as it were, from under the malleolar arch. In other instances, again, one of the sharp angular fragments connected with the bone may be pressed forwards, and uniting in this position, give rise to permanent deformity. But whatever care be employed, or apparatus applied, it will be found impossible in some cases to replace one of the thin angular fragments, if it become twisted on its axis, and project sharply under the skin.

If the foot be twisted much outwards, as often happens in Pott's fracture, Dupuytren's splint may be applied to the inner side of the limb, so as to counteract the displacement (Fig. 260). In applying the apparatus, three points require attention. 1. The pad should be folded double at the lower end, and not descend below the upper fragment, so as to form a fulcrum, across which the foot may be drawn to the inner side. 2. The bandage should be applied first to the upper part of the splint. It should not be carried above the knee, but terminate just below the flexure of the joint. 3. The knee should be bent, so as to flex the leg on the thigh, and thus to relax the strong muscles of the calf, which, by drawing up the heel, and causing the toes to point downwards, offer a serious obstacle to the maintenance of the foot in a good position. Much stiffness is always left after union has taken place, the ankle remaining rigid, weak, and useless for a long time.

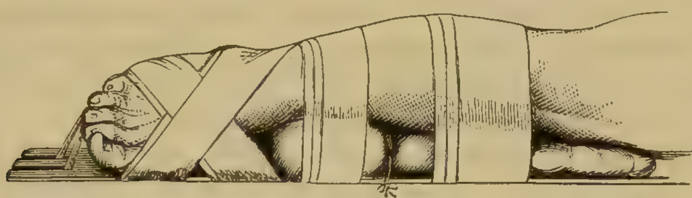


Fig. 260.—Application of Dupuytren's Splint in Pott's Fracture.

This is especially the case in elderly people. When this fracture occurs in advanced life the mobility of the ankle-joint is rarely, if ever, regained, and lameness is the almost inevitable result, due partly to adhesions in the sheaths of the tendons, partly to some slight displacement of the articular surfaces. In such cases wrenching, followed by passive motion, douches and frictions may do much to restore the mobility of the fibres.

In Pott's fracture, where the malleolar arch is split through, a peculiar deformity is apt to result, consisting of widening of the lower end of the leg by separation of the malleoli. The astragalus is driven upwards, the shaft with the inner malleolus projects somewhat to the inner side, whilst the outer half of the malleolar arch is carried outwards with the lower end of the fibula. The transverse line between the malleoli is increased by half an inch.

Fracture of the Internal and External Malleolus occasionally takes place, with great displacement of the foot backwards. It most frequently occurs from catching the heel in running down stairs. The displacement backwards is occasionally overlooked, as the malleoli having gone back with the bones of the tarsus, the appearances are very deceptive, and the patient may thus be left with the toes pointed down and an almost useless foot.

Treatment.—This displacement may be treated by the application of one of the jointed splints above mentioned (Fig. 258), or should that fail, Syme's anterior splint may be used. This is a straight splint, long enough to reach from the head of the tibia to below the foot ; its lower extremity is cut out into a deep horse-shoe-shaped notch, wide enough to take the instep between the two prongs. It must be padded by a double pad, made of two rolls of cotton wool in calico ; these must lie one on each side of the spine of the tibia to protect it from pressure. The splint is then firmly bandaged to the anterior aspect of the leg, and the foot is drawn forward by bandages passing round the prongs and under the heel, the heel being protected by a thick soft pad.

Compound Fracture into the Ankle-joint is necessarily a serious and dangerous accident. In this injury, the edge of the fractured bone cuts through the integument by apparently a clean and simple wound, but the subjacent areolar tissue is often widely torn, and the deep-seated mischief may be far more extensive than that which the Surgeon would be led to expect from the appearance of the external wound. When the wound is made by the sharp edge of the root of the malleolus, as soon as the foot is replaced and the tension on the skin caused by the eversion is relaxed, the opening no longer corresponds to the seat of fracture, and consequently, if decomposition of the discharges takes place and the joint becomes filled with septic matter, there is no efficient means of drainage, and suppuration, with great tension and deep burrowing of pus, ensues ; the ankle-joint is destroyed and secondary amputation often becomes necessary. The injury, however, is usually recovered from with a good and useful limb when the patient is young and of sound constitution, and the dangers of inflammation and suppuration are prevented by the establishment of good drainage, by the prevention of decomposition, and by perfect rest. As age advances, however, and the constitution becomes broken, less is to be expected from conservative surgery.

In the *Treatment*, the course to be pursued will depend upon the extent of the injury. If the fracture be not much comminuted, the wound in the soft parts clean cut and but moderate in extent, and the large vessels of the foot uninjured, an attempt should be made to save the limb. The wound and the joint must be carefully cleaned with carbolic-acid-lotion. If it is evident that the drainage is insufficient the wound may be enlarged in such a way as to provide an efficient exit for the discharges from behind the malleolus ; any splintered fragments must be removed and the wound left open to heal by granulation, some form of antiseptic dressing being applied. The limb must be firmly fixed on a splint ; as a rule a lateral splint applied to the side opposite the wound will be found the most convenient. If the wound is on the inner side, as it almost always is, the limb must be flexed and laid on its outer side ; should it be on the outer side it may be swung in a Salter's cradle. Occasionally a McIntyre's splint (Fig. 253) may be found the most convenient, but it must be swung from a cradle and not fixed to a block ; perfect fixity of the foot is here of the first consequence.

If there be great comminution of bone, with dislocation of the foot, and perhaps rupture of the posterior tibial artery, in a person at or above the middle period of life, amputation should be practised. In a young subject, such a serious injury even as this may be recovered from, if the Surgeon remove loose fragments and saw off the splintered ends of the bone.

If much of the fibula should require removal, Stromeyer has recommended that the limb be amputated instead, lest an useless foot, affected with a kind of valgus, be left. But, in children and young subjects, this inconvenience and deformity may be overcome by mechanical means ; and the probability of its occurrence would not, in my opinion, justify amputation.

In badly set fractures near the ankle-joint, great deformity with much impairment of use of the foot may result. In these cases the inner malleolus will be found to project greatly, the fibula to be curved inwards above its lower third, so as to form a concavity above the external malleolus, and the foot to be turned somewhat outwards (Fig. 261). I have in two instances of such ill-set fractures succeeded in removing the deformity to a considerable

extent, even after as lengthened a period as a year and a half or two years, by dividing the fibula subcutaneously by means of a narrow-bladed saw at the seat of greatest concavity, forcibly adducting the foot, and then putting up the fracture in a Dupuytren's splint.

FRACTURES OF THE BONES OF THE FOOT almost invariably result from direct violence, and are usually accompanied by bruising and injury of the soft parts; hence much displacement is rare, and, when the fracture is simple, rest and position alone are necessary. Compound fractures of the tarsal or metatarsal bones, attended by much bruising and laceration, usually require partial removal of the foot, its disarticulation at the ankle-joint, or amputation in the lower third of the leg, according to the extent and severity of the injury.

Fig. 261.—Badly set Pott's Fracture, curable by operation.

The **Calcaneum** may be broken by direct violence, as when a person jumping from a height alights forcibly on his heel, and thus fractures the bone. In this way the bone is usually simply broken across in front of the ligaments without displacement. I have, however, seen both calcanea extensively comminuted, being shattered to pieces, in the case of a lady, who, falling from a window on the third story, alighted on her heels. In some rare cases, by the powerful contraction of the strong muscles of the calf, the posterior part of the os calcis is torn away from the rest of the bone.

Signs.—When the os calcis is simply broken through at the posterior part behind the insertion of the lateral ligaments, the detached fragment will be drawn up by the action of the strong muscles of the calf. But when the fracture occurs across the body of the bone, no displacement can take place, owing to the lateral and interosseous ligaments keeping the posterior fragment in position, and preventing its being drawn away.

In the first form of fracture, the pain, swelling, flattening of the heel, and prominence of the malleoli, indicate the nature of the injury, even though crepitus be wanting. In the second variety, the mobility of the fragment, and its projection posteriorly owing to the action of the muscles of the calf, point to the existence of the fracture, which is confirmed by the occurrence of crepitus.

In the *Treatment* of these injuries, keeping the part fixed by means of bandages and splints, with due attention to the relaxation of the muscles attached to the tendo Achillis, by flexing the leg and extending the foot, is all that can be done. Union occurs probably by bone in some cases, though very commonly by fibrous tissue.

The **Astragalus** alone is rarely broken. Ten recorded cases of this injury have been collected by Monahan: in nine of these the fracture occurred from falls from a height on the foot; in one only from direct violence. I have seen two cases of fracture of the astragalus without implication of any other of the tarsal bones. In one case it was the result of direct violence; a cart-wheel passing over the foot occasioned a fracture of the astragalus through its neck.

There was no material displacement, but the line of fracture could be readily felt, and crepitus was very distinctly elicited on flexing and extending the foot. No better treatment can be adopted in such a case than the starched or plaster-bandage.

In the other case the fracture was the result of indirect violence, the patient, a man about 30 years of age, falling from a height of about eight yards, and alighting on his feet. Here the fracture was evidently occasioned by the malleolar arch being forcibly driven downwards on the foot, so that the astragalus was broken across transversely just in front of the surface that articulates with the tibia—the line of fracture running obliquely downwards and backwards, so that the whole of the upper and posterior part of the bone was detached. This large fragment was widely displaced, being driven outwards and backwards, so as to lie between the fibula and the tendo Achillis, lacerating the skin to the extent of about one inch longitudinally, and projecting through the opening thus made. The foot presented a singular degree of deformity, which is represented in the annexed figure (Fig. 262). The outer malleolus projected greatly; and immediately behind this the displaced fragment could be felt and seen partially protruding through the rent in the skin. The inner malleolus was depressed; there was a deep hollow below this. The os calcis was apparently turned somewhat towards the inner side of the foot. The sole was arched, the skin much wrinkled, and the great toe forcibly flexed. There was a deep transverse furrow in front of the ankle-joint. On discovering the nature of the accident, and seeing the hopelessness of reduction, or rather the impossibility of maintaining the displaced fragment in position, I cut down upon it by enlarging the opening through which it showed itself, and then, seizing it with strong bone-forceps, twisted it out, dividing the ligamentous connexions. The case was then treated as one of compound dislocation of the ankle-joint. About a month after the accident, the patient died of pyæmia; and, on examining the foot, it was found that the anterior portion of the astragalus had been splintered into seven fragments, which were retained in place by the pressure of the surrounding parts. No other bone of the tarsus was injured, nor was the malleolar arch fractured. Of this splintering of the anterior fragment, there was no evidence during life; nor was there any reason to suspect it, as there was neither crepitus nor displacement. The extent of the fracture showed the immense force with which the malleolar arch had been driven downwards on the astragalus by the weight of the patient's body.

Fig. 262.—Comminuted Fracture of Astragalus. Displacement backwards.

The only similar case with which I am acquainted is one recorded by Morris. In this the displaced fragment did not occasion a wound of the integument. It was excised owing to the impossibility of reducing it; but the anterior part of the astragalus which was left fell into a state of caries, which spread to the other tarsal bones, rendering amputation of the foot necessary.

The other tarsal bones are but very rarely fractured, except in crushes or gun-shot injuries of the foot. The **Scaphoid** I have once seen fractured by a

fall. It was in the case of a man who fell down the shaft of a lift at an hotel, about 60 feet deep, receiving injuries to the chest and spine that eventually killed him. He appeared to have alighted, in the first instance, on the right foot, the os calcis of which was extensively fractured, and the scaphoid broken across without displacement, the astragalus being uninjured.

In all cases of fracture of the tarsal bones, whether simple or compound, with so much displacement as to render reduction difficult and its maintenance impossible, the best course to be pursued is that of cutting down upon and removing the displaced fragment. I know not what else can be done.

Fracture of the Metatarsal Bones usually occurs from direct violence, as by the passage of the wheel of a cart or railway-carriage over the foot, and is then attended with so much laceration and bruising of the soft parts as not unfrequently to render amputation necessary. I have in one instance known the three outer metatarsal bones broken by a person jumping from a height. But most commonly their elasticity saves them, and the ankle-joint gives way in such an accident. There is but little, if any, displacement in these cases; and unless the soft parts be so damaged as to require amputation, the support of a starched or plaster bandage is usually all the treatment that is necessary.

CHAPTER XXII.

DISLOCATIONS.

By a *Dislocation* is meant the more or less sudden and complete displacement of one of the bony structures of a joint from the other. In the ball-and-socket joints, as the hip and shoulder, the osseous structures may be completely separated from one another, the dislocation then being **Complete.** In the hinge-joints, as the elbow and knee, the osseous surfaces commonly remain partially in contact, though displaced from their normal relations to one another : here the dislocation is **Incomplete.** In most dislocations the integuments covering the displaced bones are put greatly on the stretch ; but in some they are ruptured, and then the dislocation is **Compound.** Besides these varieties, Surgeons recognize **Spontaneous** dislocation, in which the displacement does not occur from external violence. In other cases again, the dislocation arises from **Congenital** malformation of the joint, in consequence of which the bones cannot remain in proper apposition ; and finally, dislocation may take place slowly and gradually as a result of disease in the articulation and surrounding tissues. This is termed **pathological** dislocation.

It is customary nowadays to describe dislocations of the distal bone or the more movable bone; formerly, dislocation of the proximal bone was often spoken of.

Causes.—Dislocation is **Predisposed** to by various conditions, amongst which the nature of the joint appears to exercise most influence ; ball-and-socket joints being more liable to dislocation than any of the other articulations, whilst in some of the synchondroses it never occurs. Krönlein states that 51 per cent. of all dislocations occur at the shoulder joint, 27 per cent. at the elbow, and 2 per cent. at the hip. These statistics have been obtained from the combined records of the in- and out-patient practice of the hospitals in Berlin, whereas those published by Malgaigne and some others have been derived from in-patient practice only, and are consequently very erroneous.

Dislocations are seldom met with in children, in whom separation of the epiphysis from the shaft more readily takes place. When they do occur it is most frequently at the elbow-joint. Krönlein states that out of 400 dislocations treated in the hospitals at Berlin, 22 were met with in this situation in children under ten years of age. I have had under my care a child, just one year old, with dislocation of the head of the femur on the os pubis, occasioned by another older child dragging it along the ground by its leg ; Kirby and Madge have both seen dislocations of the femur on the dorsum ilii in children of three and three and a half years old ; and Travers has seen the hip dislocated in a boy five years of age. In old people the bones are so brittle, and the ligaments so tough, that violence causes fracture rather than dislocation. Hence it is principally in young and middle-aged subjects that dislocations are met with. This is well illustrated by an analysis of 84 cases of dislocations of the hip-joint, collected by Hamilton : of these, 15 occurred under 15

years of age, 32 between 15 and 30, 29 between 30 and 45, and 8 between 45 and 85. They are necessarily far more common in men than in women, from the nature of their respective occupations. Thus, according to Hamilton, of 115 dislocations of the hip, only 11 occurred in women.

The articular ends of the bones of the extremities are kept in their proper positions by the arrangement of the osseous and ligamentous structures of the joints, aided by the continuous tension of the muscles; and considerable external violence may be applied to a limb without dislocating it. If, however, the muscles be taken by surprise, or if they have been weakened by previous injury of any kind, the joint becomes predisposed to dislocation, and may be displaced under the influence of very slight causes; especially if it be one where the articulating surface is shallow and the ligaments are comparatively weak. In this way the same joint may be repeatedly dislocated. Thus I have seen a man whose humerus had been dislocated between forty and fifty times, owing to a weakened state of the deltoid.

The **Direct Causes of Dislocation** are *external violence* and *muscular action*. *External violence* may act directly upon a joint, forcing or twisting the articular ends asunder, as happens when the foot is displaced by a twist of the ankle, or when the thumb is dislocated backwards by a blow. But more commonly the force acts at a distance from the joint that is displaced, and the head of the bone is thrown out of its socket by "the lever-like movement of the shaft," as happens when the head of the humerus is dislocated by a fall on the hand, or when the head of the femur is dislocated.

Muscular action alone may cause the dislocation of a bone, even though the part be previously in a sound state. Thus, the lower jaw has been dislocated by excessive gaping, and the humerus by making a violent muscular effort. If the joint have already been weakened by previous injury or disease, muscular action is especially apt to occasion its displacement. Congenital dislocations have been supposed to arise from irregular muscular contractions in the fœtus, by which the bones are displaced, and the normal development of the joint is interfered with. In dislocations of the ball-and-socket joints, after the head of the bone has been thrown out of its articular cavity, it is often still further displaced by the contraction of the muscles, which continues until they have shortened themselves to their full extent, or until the dislocated bone comes into contact with some osseous prominence that prevents its further displacement.

Signs.—The existence of a dislocation is rendered evident by the change in the shape of the joint, and in the relation of the osseous prominences to one another: by the articular end of the displaced bone being felt in a new position; and by an alteration in the length of the limb, and in the direction of its axis. Besides this, there are impaired motion, both active and passive, of the injured articulation, and pain in and around it. It should, however, be borne in mind that fracture may exist with the dislocation; hence the mobility may be increased. In examining a patient for a supposed dislocation the Surgeon should never fail to compare the injured joint with that on the other side of the body.

Effects.—The effects of dislocation on the structure of a joint are always serious. The bones are occasionally fractured as well as displaced, more particularly in hinge-joints: the cartilages may be injured; and the ligaments are always much stretched and more or less extensively torn, the capsule of the

joint suffering especially. This is always torn by the pressure of the head of the bone in dislocation of ball-and-socket joints: in those of hinge-joints, it may escape. The situation of the slit in the capsule is of great importance in reference to reduction. It commonly occurs in the shoulder towards the attachment around the glenoid cavity; in the hip, as Busch has pointed out, at the acetabular margin. In many cases, the muscles and tendons in the immediate neighbourhood are lacerated as well as displaced, and the vessels and nerves compressed. The skin is commonly stretched, and sometimes ruptured, when the dislocation becomes *compound*. If the dislocation be simple, and if reduction be speedily effected, the injuries are soon repaired; and although a good deal of stiffness may continue, the functions of the joint are, in general, not permanently interfered with.

If the dislocation be left unreduced, important changes take place within and around the joint, in the bony structures, the ligaments, capsule, and muscles. The changes in the bony structures are very slow, differing in this respect materially in ordinary traumatic dislocations, from what takes place in a joint that has been dislocated as the result of disease. If the articulation be of the ball-and-socket kind, as the shoulder or hip, the cavity undergoes very gradual changes in outline and depth; its circumference becomes contracted, less regular, more angular, and the hollow eventually shallows. These changes are so slow in the adult, that a year or more will elapse before they have gone on to such a degree as to prevent the displaced head of the bone from being put back. In children and young people they are more rapid and complete, and the cavity fills up with a dense fibrous tissue. In the hinge-joints, the articular ends of the displaced bones become altered in shape—flattened or angular, with the osseous projections less strongly marked. The incrusting cartilage is gradually absorbed, and the bone smoothed. The ligaments are shortened and wasted; and a false joint forms around the articular end of the bone in its new situation. In some cases, the bone upon which the dislocated head rests becomes depressed into a shallow cup-shaped cavity, so as to receive it; in others the depression is formed by the elevation of a rim of callus upon the adjacent bone; and in both instances the areolar tissue in the neighbourhood becomes consolidated into a fibrous capsule surrounding and fixing the bone in its new situation, and usually permitting but a limited degree of motion. The soft structures that have been lacerated at the time of the dislocation become matted together by cicatricial fibrous tissue; the muscles shorten, and at last undergo fatty degeneration if the position of the limb is such that it is incapable of movement. The neighbouring vessels and nerves may become attached to the new joint, or their sheaths become incorporated with the altered structures in contact with them.

Treatment.—In the treatment of dislocations, the first and principal indication consists in replacing the bone in its normal situation as speedily as possible. In doing this, the Surgeon has two great difficulties to overcome: 1, the contraction of the muscles of the part; and, 2, the resistance arising from the anatomical structure of the joint and the laceration of the capsule.

1. One great obstacle to reduction in most dislocations is the tonic *contraction of the muscles* inserted into or below the displaced bones; and in the reduction of the dislocation the Surgeon's efforts are partly directed to overcome this contraction. The amount of resistance due to muscular contraction may be measured by the effects produced by anæsthetizing the patient. So

much of the resistance as is overcome by putting the patient under the influence of ether or chloroform, is due to muscular contraction. All that which continues after this, is due to purely mechanical causes connected with the arrangement of the osseous and ligamentous structures of the joint, or with the injury inflicted on them. The resistance offered by the muscles is of several different kinds, and is dependent on different causes. The influence exercised by the patient's will, and the tonic contraction or passive force exerted by the shortened and displaced muscles, undoubtedly often offer great obstacles to reduction. But more serious than these by far is the reflex or spasmodic action, which the patient is unable to control, and which can be overcome only by force, by faintness, or by the paralysing influence of anæsthetics. The longer the dislocation is left unreduced, the more powerful does the resisting force become; being less at the moment of the accident and immediately afterwards, than at any subsequent period. Hence reduction should be attempted as soon as possible after the occurrence of the accident; and, if the patient be seen at once, the bone may sometimes be replaced without much difficulty by the unaided efforts of the Surgeon. Thus Liston reduced a dislocated hip by his own endeavours immediately after the accident occurred. If a few hours have elapsed, the muscular tension becomes so great that special measures must be adopted in order to diminish it; and if some weeks or months have been allowed to pass by, the dislocation may have become irreducible, partly owing to permanent secondary shortening of the muscles, which it is impossible to overcome, but chiefly to the matting together of the surrounding tissues, and the formation of adhesions about the head of the bone. The muscular resistance is greatest when an attempt is made at reduction by forcible traction in the direction of the longitudinal axis of the limb, and parallel to the course of the muscles.

In the reduction of a recent dislocation, advantage may sometimes be taken of the occurrence of faintness, or of the patient's attention being distracted to other matters, the muscles being then taken, as it were, by surprise, and the bone readily slipping into its place. Such aids as these, however, cannot be depended upon; and muscular relaxation should be induced by the administration of chloroform or ether. By the employment of these valuable agents, the muscles of the strongest man may be rendered so perfectly flaccid and powerless in a few minutes as to offer no opposition whatever to reduction, which is thus wonderfully simplified and facilitated. In no department, indeed, of practical surgery has the administration of anæsthetic agents been attended by more advantageous results than in this.

2. The reduction of dislocations is impeded also by the mechanical resistance arising from *the anatomical structure of the joint and its ligaments.* The observations of Bigelow, Busch, and others have proved that this impediment to reduction is of more importance than was formerly supposed. Bigelow has shown by dissection of dislocations of the hip, produced in the dead body, that the characteristic attitude of the limb and the difficulty of reduction is due to the tension of the unruptured parts of the capsule and its accessory bands consequent upon the abnormal position of the head of the bone, and thus it is not until these are relaxed, by placing the limb in the proper position, that reduction can be accomplished. Busch has shown that the same is true of the shoulder joint, the characteristic position of the chief forms of dislocation being maintained when the whole of the soft parts have been removed except the

ligaments. If the ligaments are more extensively torn, the limb falls into positions quite different from those ordinarily set forth in descriptions, giving rise to those rare displacements which Bigelow has classed as *irregular dislocations.*

In other cases, the head of the bone may be grasped by the edges of the rent in the capsule through which it has passed, and reduction is almost impossible till the limb is placed in such a position as to relax them thoroughly. In hinge-joints, the bony processes may get locked into each other, as, for example, in dislocation of the bones of the forearm backwards, when the coronoid process hitches against the lower end of the humerus. The false position is then maintained chiefly by the tonic contraction of the muscles.

Bearing these facts in mind, the reduction of a dislocation is effected by the following means :—

Mechanical contrivances are much less frequently used for the reduction of dislocation, since the employment of anæsthetics, than formerly. It is, however, occasionally necessary to employ apparatus calculated to fix the articular surface from which the bone is dislocated, and to draw down or disentangle the displaced bone to such an extent that it may be replaced on the surface from which it has escaped. If the patient have not been anæsthetized, it will be found that, when the bone is well brought down by the extending force so as to be opposite its articulation, and disentangled from osseous points upon which it may have hitched, or from the edge of the slit in the lacerated capsule, it will be drawn at once into its proper position by the action of its own muscles, with a sudden and distinct snap ; the muscles of the part being the most efficient agents in the reduction, so soon as the bone is placed in a position for them to act upon it. When, however, the patient has been placed under the influence of chloroform, the muscular system being thoroughly relaxed, the bone will not slip into its place with a snap or sudden jerk, but is reduced more quietly, and rather by the efforts of the Surgeon than by any sudden contraction of its own muscles. It is important to note these differences in the mode of reduction ; lest the Surgeon, when chloroform has been fully administered, failing to hear the snap or feel the jerk which he expected, should imagine that the bone has not been reduced, and continue to use an improper degree of extension.

The purely mechanical means for the reduction of dislocations are sufficiently simple : the patient's body, and the articular cavity whence the luxated bone has escaped, are fixed by a split sheet, a jack-towel, a padded belt, or some such contrivance, by which *counter-extension* is practised. In some cases the hands of an assistant, or of the Surgeon himself, or the pressure of his knee or heel, constitute the best counter-extending means. Extension may be made either by the Surgeon grasping the limb to be reduced and drawing it downwards, or else by means of a bandage or jack-towel fixed upon the part, with the clove-hitch-knot applied in the way represented in the annexed cut (Fig. 263). If more force be required, the multiplying pulleys (Fig. 298) may be used, by which any amount of extending force that may be required can readily be set up and maintained. When any powerful extending force is applied, the skin of the part should always be protected from being chafed by a few turns of a wet roller. The extension must be made slowly and gradually without any jerking, so as to secure equality of motion as well as of traction. In this way the contraction of the muscles is gradually overcome,

whereas sudden and forcible extension might excite them to reaction. The traction should be commenced in the newly acquired axis of the limb, and by this means the dislocation is often readily reduced; but if it does not yield at once, the direction should be changed, while the traction is kept up, to that which relaxes to the fullest extent the untorn ligaments or bands of the capsule. This will in most cases correspond to the position of the limb at the time of the accident. The head of the bone is thus made to pass along the same track which it has torn for itself in being dislocated, and thus is replaced without the infliction of any additional violence on the surrounding tissues.

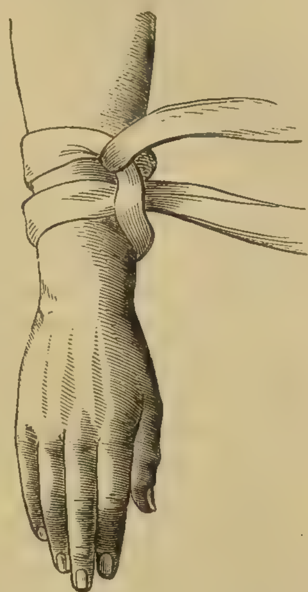


Fig. 263. — Bandage applied for Extension: Clove-hitch Knot.

The question whether the extending force should be applied to the bone that is actually displaced, or to the further end of the limb, has been much discussed, and appears to have received more attention than it deserves. It is true that, by applying the extending force to the displaced bone itself, the Surgeon has greater command over its movements, with less chance of injury to the intervening bones; whilst, by applying the extending force to the lower part of the extremity, he has the advantage of a longer lever for the reduction of the head of the bone. This lever, however, it must be remembered, is in many cases a broken one; and it cannot be made to act if the bone have to be replaced in the direction of flexion of the joints that exist in its course. For this reason, we find that some dislocations are best reduced by applying traction to the bone itself that is displaced, as in luxations of the femur and of the bones of the fore-arm; whilst, in other cases, as in the dislocations of the humerus, most advantage is gained by applying the extending force to the end of the limb. But I look upon these points as of comparatively little consequence; believing that, when the patient is not anæsthetized, the muscles of the limb themselves effect the reduction, without the necessity of the Surgeon employing any very powerful lever-like action of the bone; and that, when the patient is paralysed by chloroform, the bone is in most cases readily replaced by the simple movements impressed directly upon it, or even upon its articular end, by the hands of the Surgeon.

The force required in effecting the reduction of recent dislocations is often very considerable. So great is the resistance offered, that in some cases the dislocated bone has given way under the traction. I am acquainted with cases in which the humerus and the neck of the femur have been broken in effecting the reduction of *recent* dislocations. This accident does not always appear to have been the result of any improper or unskilful employment of force, but in some cases to have occurred from natural weakness of bone. We know that "spontaneous" fractures take place from muscular action, often of a very slight kind: and we can easily understand that, if a bone that would be liable to such ready fracture happened to be dislocated, it would almost of necessity give way under the influence of the extending or lever-like force required to replace it.

Manipulation of the limb—that is, impressing upon it certain movements of extension and flexion, of adduction, abduction, and rotation—is, whenever possible, the best mode of reducing a dislocation. The movements impressed on limbs are guided by the anatomical relations of the parts concerned in the dislocation, and have for their object to relax untorn ligaments and parts of the capsule which are rendered tense by the abnormal position of the head of the bone; to bring the head of the bone opposite the rent in the capsule; and sometimes, by using the attachment of the untorn ligament as a fulcrum; and the limb as a lever, to force the head into the socket. In other cases the particular movement may have for its object to dislodge a process of bone from another against which it has hitched, or to relax the chief muscles which hold the bone out of its place. When the patient is anæsthetized, and all muscular resistance has thus been removed, any remaining difficulty in effecting reduction must be due to purely mechanical causes dependent on the disarrangement of the bones and ligaments. Under the older methods of treatment, where much force was employed by pulleys or other similar contrivances, these were often torn through. But, since the introduction of manipulation, the Surgeon effects the reduction by a far less degree of force, replacing the bone on simple mechanical principles, by relaxing the ligaments and disentangling the bones from one another. The situation and extent of the laceration of the capsule of the joint are also of great importance as offering an obstacle to reduction, in some cases constricting the neck of the bone, in others having one lip of the slit pressing against the bone in such a way as to resist all efforts to move it. An extreme degree of force is required to tear through and thus overcome obstructions of this kind; but they may readily be relaxed and slipped aside by skilful manipulation and attention to the position of the limb.

Manipulation has been especially useful in dislocation of the hip, shoulder, and knee, and the details of the process will be described with the special dislocations of these joints.

After-Treatment.—After the dislocation has been reduced, the limb must be kept firmly fixed and at rest by proper bandages or splints for two or three weeks, so as to allow proper union to take place in the torn capsule and neighbouring structures. If this is not done the joint may be permanently weakened and be liable to a recurrence of displacement from very slight causes.

Any consecutive inflammation may often be prevented by the continuous application of cold; and, if set up, must be treated by local antiphlogistic measures. The fixation of the joint must not be maintained for too long a time, lest adhesions, often of a painful character, form. These may be avoided by passive motion. If they have formed, they may readily be broken down by the manipulations commonly employed in such cases by "bone-setters," who, fixing the joint by pressure of the thumb on the painful spot, in a manner well described by W. Hood, impart sudden and forcible movement to the limb, by which adventitious bands are ruptured.

Dislocations of Old Standing.—If a dislocation have been left unreduced for some weeks or months, changes, which have already been described, take place in and around the displaced articular structures, the double effect of which is to render the replacement of the bones in their normal position more and more difficult as time goes on, and to lead to the formation of a new though imperfect articulation at the seat of the displaced bone.

When a dislocation has been left permanently unreduced for a considerable length of time, as for years, the amount of utility in the limb will depend partly on the kind of joint that has been dislocated, partly on the particular variety of dislocation that has occurred. Thus, as a general rule, greater freedom of movement and greater utility of limb will be found in old-standing dislocations of ball-and-socket than of hinge-joints. But in ball-and-socket joints some dislocations will, if left unreduced, be attended with less evil consequences to the patient than others. Thus, in the *subglenoid* dislocation of the shoulder and the *sciatic* of the hip, the limb will recover itself to a greater extent than in the other forms of the same kind of injury affecting these joints.

Treatment.—In cases of very old and irremediable unreduced dislocation, much may be done by means of regularly conducted passive movements to increase the mobility of the part, and by means of friction and warm douches to relieve the painful stiffness. In cases not so old, but in which some time has elapsed since the occurrence of the dislocation, two questions always present themselves to the Surgeon :—1. Is it possible to replace the dislocated bone ? 2. Is it desirable or prudent to attempt reduction ?

The possibility of reducing the dislocation will depend partly upon the joint that is dislocated and the nature and extent of the dislocation, but chiefly on the length of time during which the bone has been out of place. Dislocations of the orbicular joints generally can be reduced at a much later period than those of the ginglymoid ; those of the shoulder can be reduced after a longer lapse of time than those of the hip. The subglenoid dislocation of the shoulder and that of the hip on the dorsum ilii are capable of reduction at a later period than the other luxations of the same joints.

The *latest period* at which reduction is possible has been variously estimated by different Surgeons. Sir A. Cooper gives three months for the shoulder and eight weeks for the hip. As a general statement, this was no doubt tolerably correct at the time when it was made, although reduction had been effected at later periods than those given by Cooper. Thus Breschet reduced a dislocation of the hip at the 78th day, and Travers at the fifth month. But we may now go far beyond this as the limit of *possible* reduction. Brodhurst has reduced the shoulder on the 175th day ; Smith (U.S.) in one case at the seventh month, in another at ten months and a half ; Sédillot one at a year ; Blackman of Cincinnati, a dislocation of the femur on the dorsum ilii, at six months ; Dupierris of the Havana, one at over six months, in a boy, and this without chloroform ; and R. W. Smith, after nine months had elapsed.

The **Obstacles to the Reduction of old-standing dislocations** are rather pathological than physiological and anatomical as in the case of recent displacements. They are of several distinct kinds :—1. The powerful tonic contraction of the shortened and displaced muscles ; 2. The organic changes that have taken place in the muscles partly from the contraction of the cicatricial tissue formed in the repair of the lacerations which occurred at the time of the injury, and partly from the shortening that has taken place to adapt the muscles to the altered relation of the head of the bone ; 3. Adhesions that form between the lacerated capsule and the muscles and the displaced head of the bone ; 4. Lastly, as a more remote effect, pathological changes in the articulating surfaces themselves, by which their shape becomes altered and the socket shallowed, contracted, and perhaps ultimately obliterated.

In order to overcome these obstacles a considerable amount of force must be used, as adhesions and contractions have to be stretched and torn asunder. This is effected by the multiplying pulleys and by manipulation under chloroform. In employing the necessary force, care must be taken to protect the skin from abrasion, or even laceration, by the use of wet flannel-bandages or wash-leather. The force exercised by the pulleys must be considerable; but it should be accompanied by free rotatory manipulations and movements of the head of the bone, so as to loosen it from its adhesions; and reduction will usually be effected in this way rather than by forcible traction only.

Anæsthesia is of inestimable service in these cases; and it is by its means that the Surgeon has been enabled to prolong materially the limit of possible reduction. But, in the reduction of old dislocations, anæsthetics do not afford exactly the same kind of service as in those of recent date. In a recent dislocation one great obstacle is muscular contraction; and, by relaxing this, anæsthetics enable the Surgeon to replace the bone at once without difficulty. In old dislocations the obstacles, as has just been stated, consist in various pathological changes that have taken place around and in the displaced bones. These conditions cannot be influenced by anæsthesia; and hence, except as a means of producing insensibility to pain and preventing instinctive or voluntary muscular resistance, chloroform will not aid the Surgeon.

It must be borne in mind that the reduction of old dislocations is not only a work of very considerable difficulty, but also of danger. If several months have elapsed, the obstacles arising from the pathological changes already mentioned will usually be so obstinate as to render the reduction impossible without the employment of a dangerous amount of force; and in many cases they will prevent reduction, whatever force be employed.

The **Accidents** liable to occur during attempts to reduce old dislocations, whether successful or not, are the following:—1. Laceration of the skin by the constriction and pressure of the bands to which the pulleys are attached. 2. Laceration of muscles: thus the pectoral has been torn through in attempting reduction of old dislocation of the shoulder. 3. The development of inflammation and suppuration around the dislocation, by the violence to which the soft parts have been subjected. From this cause death has several times resulted, in attempts at reducing old hip-dislocations. 4. Extensive extravasation of blood from the rupture of small vessels in the lacerated soft parts, giving rise to wide-spread ecchymosis. 5. Laceration of one of the larger veins. A patient of Froriep's died from this cause, after rupture of the axillary vein, in an attempt to reduce an old dislocation of the shoulder. 6. Laceration of an artery, and the formation of a diffused traumatic aneurism. This serious accident has happened at least twelve times in attempted reduction of old dislocations of the shoulder. The brachial artery has also been torn in attempted reduction of dislocated elbow. 7. Laceration of neighbouring nerves. Those of the axillary plexus have been torn in attempted reduction of dislocation of the shoulder, and the median in that of the elbow. Flaubert has recorded a case in which the four lower nerves entering into the brachial plexus were torn away from the cord. The patient, a woman 70 years of age, died eighteen days afterwards, with paralysis of both arms and of the leg on the same side as the injury. 8. Fracture of the dislocated bone. This

serious accident has usually happened when the Surgeon, after the employment of extension, has attempted to put in force transverse movements of the bone, or has used the bone as a lever; it has given way, usually, high up near the head, at other times in the shaft. It is probable that in most cases this has been predisposed to by the bone having become weakened by want of use. It has occurred several times in the humerus, and at least eight times in the femur, in attempts at reducing old dislocations of these bones. In most of the recorded cases the bone has readily united, and the condition of the patient has not been materially, if at all, influenced for the worse, except that reduction of the dislocation has necessarily been rendered impossible. 9. Neighbouring bones have been fractured, such as the ribs and the glenoid cavity in the endeavour to reduce dislocation of the shoulder, and the acetabulum in attempted reduction of a luxated hip. 10. The limb has actually been torn off. This remarkable and distressing accident happened to Guérin of Paris, in attempting the reduction without pulleys, but merely by the traction of four assistants, of a dislocation of the shoulder of three months' standing, in a woman 63 years of age, the limb being suddenly torn off at the elbow. The patient died on the twelfth day; and on examination, the bones were found porous, the muscular and other soft structures pulpy, the limb having evidently lost its natural strength and elasticity.

The occurrence of these various accidents and injuries, in the attempted reduction of old dislocations, cannot always be justly attributed to the employment of an improper degree of force by the Surgeon. The liability to them must rather be looked upon as a necessary and inevitable accompaniment of all attempts at putting back into its place a bone which has been dislocated, and left unreduced for many weeks or months. During this period the bone usually contracts adhesions of a very dense kind to the parts amongst which it lies; and, as it cannot be replaced in its articular cavity until these adhesions have been torn or broken through, it is easy to understand how, in the attempt to do this, neighbouring soft parts, vessels, or nerves may give way, or the bone itself may yield to the force that must be applied to it in order to lift it out of its new bed.

The liability to the occurrence of these accidents should make the Surgeon very cautious how he recommends an attempt to reduce old-standing dislocations. If after a time the new joint have become tolerably mobile, and be not painful, it may be better to leave the bone unreduced, rather than expose the patient to great risk, with a slender prospect of eventual success. If the unreduced dislocation be stiff and painful, much may be done by passive motion, frictions, and douches, to improve the patient's condition.

The **Subcutaneous Section** of muscles, tendons, and bands of adhesions in the neighbourhood of the dislocated joint, has been proposed by Dieffenbach as a means of facilitating reduction in old-standing cases; and he relates an instance in which, by these means, a shoulder that had been dislocated for two years was reduced. In many cases in which this plan has been tried, the success has not been commensurate with the expectations raised respecting it; and in other instances, of which I have seen two or three, the operation has been followed by sloughing and other serious evils, while it has not been attended by any benefit in facilitating reduction.

Compound Dislocation is one of the most serious injuries to which a limb can be subjected. Not only is there such extensive laceration of the soft parts

that cover and enter into the formation of the joint as to give rise to the most severe forms of traumatic arthritis, but the bones are often fractured, and the main vessels of the limb perhaps greatly stretched or torn.

The *Treatment* of a compound dislocation must be conducted on the same principles that guide the Surgeon in the management of a wounded joint, viz., rest, drainage, and the prevention of decomposition. Owing to the rupture of the ligaments and muscular attachments, there is usually no difficulty in the reduction; but the danger consists in the destructive inflammation that so frequently follows in the joint. This, as was before pointed out, is due chiefly to the accumulation of decomposing discharges in the cavity; but in the case of a compound dislocation, it is aggravated by the severe bruising and laceration of the surrounding structures. Consequently extensive inflammation and suppuration with sloughing may follow the injury. In all cases it is better not to make any attempt to close the wound by suture, as this would only interfere with the drainage, and union by the first intention is practicably impossible. Cleaning the wound and dressing it must be conducted on the principles laid down in the chapter on wounds of joints (p. 492). If the joint be a large one, the line of practice will vary according to circumstances other than the mere dislocation. Thus, if it be in the upper extremity, the patient being healthy, and the soft parts not very extensively contused or torn, the bones may be replaced, after the joint has been properly cleaned with carbolic-acid-lotion (1 in 20), or some other antiseptic solution, and may then be dressed by one of the antiseptic methods already described. Dry cold may be applied over the dressing if possible. The limb must be placed on a splint to ensure rest for about two weeks, after which if all goes well passive motion may be commenced with care. Should suppuration take place, passive motion would only ensure the destruction of the joint; the limb must then be firmly fixed on a splint with the hope of obtaining ankylosis. If there be fracture conjoined with the dislocation, resection should be practised, as was successfully done by Hey in several cases of injury of the elbow of this description; but if the soft parts be greatly injured as well, and especially if the blood-vessels and nerves of the limb have suffered, amputation must be performed. In the lower extremity, amputation is more frequently necessary; in the knee, almost invariably so. Sir A. Cooper states that he knows no accident that more imperatively demands amputation than compound dislocation of this joint. Yet there are exceptions to this rule; thus, White had a case of compound dislocation of the knee-joint in a boy, nine years of age, at the Westminster Hospital, in which he saved the limb by sawing off the condyles of the femur and reducing the bone. In compound dislocations of the ankle and the astragalus, an attempt should generally be made to save the limb, in the way that will be more specially pointed out when we come to treat of these injuries.

After recovery from compound dislocation, the joint will often remain permanently stiffened; hence attention to position during the treatment is essentially required. In many cases, however, very good motion is ultimately obtained, though the stiffness may continue for some length of time.

COMPLICATIONS.—**Fracture of the Shaft of one of the Long Bones with Dislocation of its Head** increases considerably the difficulty of reduction. In these circumstances, it has been recommended to consolidate the fracture first, and then to attempt the reduction. But to do this is only to

defer and increase the difficulties. At least seven or eight weeks must elapse before the fracture will be sufficiently firmly united to bear the requisite traction to reduce so old a dislocation; and then there will be great chance of rupture of the callus, and there will certainly be extreme difficulty in the reduction. It therefore appears to me much safer, under all circumstances, to endeavour to reduce the dislocation at once, and afterwards to treat the fracture in the usual way. In reducing a dislocation complicated with fracture of the shaft of the displaced bone, the fracture must first be put up very firmly indeed, with wooden splints completely encasing the limb. The patient must then be put fully under the influence of chloroform, which is of the most essential service in these cases; and, when the muscles are completely relaxed, extension and counter-extension being made in the usual way, the reduction may be effected. The extending means should always be applied upon the splints, so that there may be no dragging upon the fracture. In this way I have reduced, without any difficulty, a dislocation of the head of the humerus into the axilla, complicated with comminuted fracture of the shaft of the bone, in a remarkably muscular man to whom I was called by Byam; and about the same time I had under my care at the Hospital a case of dislocated elbow, with fracture of the shaft of the humerus, that was reduced with ease in the same way. The difficulty in reduction is necessarily increased by the proximity of the fracture to the dislocated joint, and when the epiphysis is broken off from the shaft and dislocated, the difficulty may be great; but it is not insuperable. Some years since, I assisted H. Smith and Dunn in the reduction of a dislocation of the humerus with fracture of the surgical neck of the bone, the displaced head lying to the inner side of the coracoid process. In this case the patient, a young man who had sustained the injury by a fall in an epileptic fit, was put under chloroform, and when he was fully anæsthetized the displaced head of the bone was easily replaced; the patient recovering with an excellent and useful arm. After the bone has been reduced, the fracture should be treated in the ordinary way.

When a **Simple Fracture extends into the Articular End of the Bone,** as in some dislocations about the elbow and ankle, there is no material increase in the danger of the case or in the difficulty of its management.

In **Compound Dislocation with Fracture of the Articular Ends,** removal of splinters, and partial resection or amputation, will be required, according to the seat and extent of injury.

Spontaneous Dislocations may occur either suddenly or gradually, and may arise from a variety of causes.

Spontaneous dislocation, if the term can be properly applied to such cases, is often met with as the result of disease of the articulation. In all *destructive inflammation of joints*, as in white swelling of the knee, disease of the hip-joint, or acute arthritis following a wound, the ligaments become softened, the cartilages are destroyed, and the bones entering into the articulation altered in shape by ulceration; and under these circumstances the articular surfaces become readily displaced under the influence of slight muscular action. To this class Volkmann has given the name of *Dislocation from Destruction.* In chronic rheumatic arthritis, especially of the smaller joints, and in the joint-affections met with in locomotor ataxy, it sometimes happens that the articular surfaces are gradually forced out of their normal relation by the pressure of osseous out-growths, springing from the bones close to the margin

of the cartilages. These are classed by Volkmann as *Dislocations from Deformity.* In another form, which was specially studied and described by Stanley, the affection is due to a paralytic condition of the muscles surrounding the capsule. In these *paralytic dislocations,* which are most common in the hip and shoulder, the head of the bone slips out without any very marked sign of disease about the joint, and certainly without any previous destruction of it. In another class, to which Volkmann has given the name of *Dislocations from Distension*, the capsule is stretched and weakened by effusion of fluid within it. These are occasionally the result of acute suppuration within the joint, the capsule becoming softened and giving way at its weakest point, and the head of the bone escaping through the aperture. In these circumstances there would be high fever and intense pain, relieved when the capsule gives way. In other cases the fluid that distends the joint is serous in character; these may be acute, but are more commonly chronic. The ligaments then become gradually stretched till they are no longer capable of maintaining the articular surfaces in position. Thus Stanley records a case in which the capsule of the hip was found to be five inches in length, and Hutton another in which the round ligament was four inches in length. In such extreme cases as these, the dislocation may take place within the capsule. The symptoms usually noted have been obscure rheumatic or neuralgic pains, lasting for some time, in the joint previous to dislocation. It may, however, occur suddenly, without any pain, the deformity of the limb first attracting attention. The affection is almost confined to the hip, but other joints may be affected, and sometimes more than one. Thus, some time ago there was a case in University College Hospital, in which both shoulders and hips were dislocated simultaneously.

Lastly, there is a variety known as *recurrent dislocations*, in which the joint, having been dislocated and reduced, the muscular and ligamentous structures have become so weakened that ever afterwards it slips out of place on the application of slight force, or at will on the patient throwing the muscles of the limb into action. These are most common in the shoulder. They may be due to incomplete repair of the capsule, or to fracture with displacement of the edge of the glenoid cavity in the shoulder, or acetabulum in the hip. Joessel has described a case in which after death the cause was found to be rupture of the supraspinatus and infraspinatus muscles, which had become retracted under the acromion without forming new adhesions to the head.

The *Treatment* of these cases is not very satisfactory. Reduction in many cannot be accomplished; while in others it may be effected readily enough, but the bone cannot be fixed in the joint. In a case of spontaneous dislocation of the hip, without any apparent disease of the joint, occurring in a young woman, I readily effected reduction by the pulleys, three weeks after the occurrence of the displacement. The limb was then fixed with the long splint, and maintained at a proper length for two or three weeks; when, in consequence of a severe bronchitic attack, it became necessary to remove the apparatus, and the displacement speedily returned. Whilst convalescent from this attack, the patient fell and fractured the displaced femur in its upper third, thus rendering it impossible to replace the bone. In another case of spontaneous dislocation of the knee, occurring in the same painless manner, the joint could not be replaced, and permanent deformity was left. After reduction in similar cases, a splint or a starched bandage should be worn for a

considerable length of time, so as to give the ligaments of the joint a chance of recovery. If there be a rheumatic tendency, it should be removed by suitable treatment; and if there be a paralytic condition of the muscles, electricity and cold douches with friction may be advantageously employed.

Congenital Dislocations are occasionally met with in the hip, shoulder, wrist, and jaw, and have of late years attracted the attention of Surgeons through the labours of Guérin, Smith, Chelius, Robert, and others. These dislocations are allied in cause and nature with other congenital deformities of the limbs, such as club-foot, &c. In them there is usually found arrested or imperfect development of some portions of the osseous articular apparatus. Whether this is original, thus causing the displacement of the bones, or consecutive upon disuse, occasioned by spasmodic action of one set of muscles or by paralysis of another, dependent on some irritation in the nervous centres, is scarcely worth inquiring here. In some cases it would appear as if faulty position of the fœtus in utero, or undue violence during birth, may have occasioned the displacement. These dislocations are probably incurable, as there is always congenital defect of structure in the articular ends of the bones, or of the socket into which they are received.

There is a peculiar form of dislocation which I have once, and only once, met with in a child, otherwise perfectly healthy, 12 years of age, and which had some resemblance to the congenital form. It was a dislocation of the head of the radius backwards, in consequence of want of development of the lower third of the ulna. In this case the radius was nearly two inches longer than the ulna. The want of development in the latter bone prevented the proper growth of the forearm; and the radius consequently, after having become slightly curved, became slowly, but completely, dislocated at its humeral end. All the movements of the bone, however, were perfect.

CHAPTER XXIII.

SPECIAL DISLOCATIONS.

DISLOCATIONS OF THE LOWER JAW.

Dislocations of the Lower Jaw are not common accidents. They occur more frequently in women than in men, and have been but very seldom met with at either extreme of life ; but Nélaton and Malgaigne relate cases occurring in edentulous subjects of 68 and 72 years of age, and Sir A. Cooper has seen the accident in a child, occasioned by another boy thrusting an apple into its mouth. These dislocations are most frequently occasioned by forcible action of the depressor muscles of the jaw—by opening the mouth too widely, as in fits of laughing, of gaping, or in attempting to take too large a bite. Occasionally this accident has resulted from blows or kicks upon the chin when the mouth is open, or from the violent strain upon the part in tooth-drawing, or rather in digging out stumps with an elevator. The mechanism of the dislocation is simple. When the mouth is opened, the interarticular fibro-cartilage with the condyle glides forwards on to the articular eminence : if this movement be continued too far, and the external pterygoid muscle contract forcibly at the same time, the condyle slips forward over the articular eminence into the zygomatic fossa, the axis of the ramus being directed obliquely backwards, and the dislocation being thus complete. In this way both condyles may be displaced, or only one. Maisonneuve and Otto Weber, by producing dislocation on the dead body, have found that the condyle lies in front of the root of the zygoma. The coronoid process rarely reaches the malar bone, but usually lies below it, being completely surrounded by the tendon of the temporal muscle. From original observation, C. Heath confirms this view of the position of the coronoid process. The interarticular fibro-cartilage is attached to the condyle, and follows its movements. The capsular ligament is stretched, but not ruptured : the external lateral ligament is tense, and passes from behind forward instead of from before backward : the internal lateral and stylo-maxillary ligaments also undergo stretching, which is increased by raising the chin. The temporal muscles are stretched according to Maisonneuve, or partly torn according to Weber.

When the dislocation is **Bilateral**, as most frequently happens, both condyles being displaced from the glenoid cavities, the signs are as follows. The incisor teeth of the lower jaw are separated from those of the upper by a marked interval, varying from half an inch to an inch and a half, and the mouth is kept more or less widely open. Deglutition and speech are impaired, the labial consonants not being pronounced ; there is dribbling of the saliva over the lower lip ; the chin is lengthened, and the lower line of teeth advanced about half an inch beyond those of the upper jaw ; the cheeks are flattened, and there is a depression in front of the meatus auditorius externus. There is also an oblong prominence in the temporal fossa between the eye and the

ear. If the dislocation be left unreduced, the patient slowly regains some power of movement over the jaw; he gradually approximates the lips, and, after a length of time, may even be enabled to bring the lines of teeth into apposition, especially posteriorly.

In the **Unilateral** dislocation, where one condyle only is displaced, the axis of the lower jaw is directed towards the side opposite to that on which the displacement exists; and the general signs are the same, but in a less marked degree, as those which are met with when both sides are dislocated. The hollow before the meatus on the injured side is, however, well marked, and serves to point out the seat and nature of the displacement, the diagnosis of which is not always readily made; indeed, R. W. Smith states that he has seen attempts at reduction applied to the uninjured side.

Sir A. Cooper has described a **Subluxation** of the jaw, most frequently met with in young and delicate women, in which, in consequence of the relaxation of the ligaments, the head of the bone appears to slip forwards upon the eminentia articularis, whenever the mouth is opened at all widely, as in gaping, laughing, &c. It may usually be ascertained by telling the patient to put out the tongue. The bone hitches, as it were, and prevents the mouth from being shut at once. Most commonly, the natural efforts of the patient are sufficient to return the head of the bone into the glenoid cavity with a cracking noise or even a loud snap.

The **Reduction** of a dislocated jaw is easily effected; it being necessary only

Fig. 264.—Reduction of Dislocated Jaw.

to push the angle of the bone downwards and backwards, and at the same time to raise the chin; by so doing the attachment of the temporal muscle to the coronoid process acts as a fulcrum, and the condyle is brought slightly downwards so as to be disengaged from the articular eminence, when the external pterygoid muscles will at once draw it into its proper position. The reduction is best effected by the Surgeon, standing before the patient, placing his thumbs, well protected by a thick napkin, or a few turns of a narrow bandage on the molar teeth on each side, and then depressing the angle of the jaw forcibly, at the same time that he raises the chin by means of his fingers spread out and placed underneath it (Fig. 264). The bone is then returned into its place with so forcible a snap that the thumbs may be severely bitten unless care be taken, or they be well protected. When one condyle only is luxated, the efforts at reduction should be applied to the injured side only. After the reduction, the four-tailed bandage should be applied, as in cases of

fracture of the jaw ; and for several days the patient must not be allowed to talk, or to eat any solid food, lest the displacement return, which it always has a great tendency to do. Very old dislocations of this bone may be reduced by the process just now described. Thus, Stromeyer replaced one at the end of thirty-five, Donovan one at the end of ninety-eight days, and Pollock one at the end of four months.

In the cases of *subluxation*, attention should be paid to the state of the general health. Tonics, more particularly iron, should be administered ; good diet, the cold bath, and open-air exercise enjoined. If, as frequently happens, there be some tenderness about the temporo-maxillary articulation, a series of small blisters may be applied over it. It is of great importance to prevent the habit of recurrence of the dislocation. This may usually most conveniently be done by letting the patient wear a small silk cap fitted to the chin and attached by four elastic bands on the top of and behind the head, as in the case of a fractured jaw.

Congenital Dislocation of one Condyle of the Lower Jaw is a remarkable and rare condition, for an acquaintance with which we are chiefly indebted to R. W. Smith. In this condition there is a singular distortion of countenance. The osseous and muscular structures on the dislocated side are atrophied, and the teeth of the upper jaw project beyond those of the lower, contrary to what occurs in the accidental dislocation : the mouth can be closed, speech is perfect, and there is no dribbling of saliva. Congenital dislocation of both condyles has not yet been observed.

DISLOCATIONS OF THE UPPER LIMB.

Dislocations of the Clavicle.—When we look at the flat character of the sterno-clavicular articulation and the very small and shallow surface on the acromion upon which the outer end of the clavicle is received, and reflect on the violence to which the shoulder is frequently subjected, we might at first imagine that dislocations of the clavicle would be among the most frequent forms of injury in this region. But this is very far from being the case. They are, indeed, rarely met with in comparison to the frequency of fractures of this bone. This is owing to several causes : amongst these are the presence of the inter-articular fibro-cartilage in the sterno-clavicular articulation, the shortness and firmness of the ligaments by which the clavicle is attached to the sternum and acromion, and the fact that any force applied to the bone is usually received in a line that corresponds to its axis, thus causing it to be bent or broken rather than luxated. The mobility of the scapula, also, has a special tendency to prevent dislocations of the outer end of the clavicle, the two bones easily moving together. Were it not for these circumstances, the bone would frequently be thrown off the small flat articular surface of the acromion.

Dislocations of the clavicle can be occasioned only by violence applied to the shoulder in such a direction, as to drive the bone inwards towards the mesial line, at the same time that the scapula is fixed.

Either the sternal or the acromial end of the clavicle may be dislocated, and the simultaneous displacement of both ends has been observed.

1. The **Sternal End of the Clavicle** may be luxated in a direction *forwards*, *backwards*, or *upwards*, being thrown before, behind, or above the sternum.

In the dislocation **Forwards**, the end of the bone can be felt in its new

position, upon the upper part of the sternum and a little below the natural level. The point of the shoulder is approximated to the mesial line, and the depressions above and below the clavicle are strongly defined. It is occasioned by blows upon the shoulder, by bending this part forcibly backwards, or by violence applied to the elbow whilst the arm is raised from the side. In some cases it occurs spontaneously, as a secondary consequence of lateral curvature or rotation of the upper dorsal vertebræ.

This dislocation, which is amongst the most frequent to which the clavicle is subject, may readily be *reduced* by pulling the shoulder outwards and backwards, while the elbow is brought in front of the mid-lateral line. The principal difficulty in the treatment consists in preventing the return of the displacement, owing to the shallowness of the articular surface upon which the clavicle lodges. With this view a pad and a figure-of-8 bandage must be firmly applied upon the displaced end of the bone, as in cases of fracture; but in dislocation the elbow should be more advanced than in fracture, and the hand brought over the front of the chest towards the opposite shoulder.

The dislocation **Upwards** is extremely rare. In 1879 there were only eight cases on record. It has been well described by R. W. Smith. In it the shoulder falls in, the sternal end of the clavicle forms a prominent tumour in front of the trachea, the sterno-mastoid muscle has an arched outline, and the axis of the bone is directed upwards, forwards, and inwards, so that the interval between the clavicle and the first rib is very considerable. The trachea and œsophagus are compressed when the patient sits up or leans forwards. Smith found on dissection that the head of the bone lay above the sternum, and rested on the sterno-hyoid muscle and trachea, the ligaments of the joint being torn through, as was also the costo-clavicular ligament (Fig. 265). He observes that the reason of its rarity is that it can be produced only by force acting on the shoulder in a very unusual direction, viz., downwards, inwards, and probably backwards. The *Treatment* consists in placing a pad in the axilla, elevating the elbow, and bringing it well to the side. But I doubt if the bone, though replaced, can be maintained in a good position.

Fig. 265.—Position of Clavicle in Dislocation of Sternal End Upwards. (Smith.)

The dislocation **Backwards** is not of common occurrence: though, according to Nélaton, there are at least ten or a dozen cases on record. This luxation appears generally to have resulted from the point of the shoulder being driven upwards, or from the hand being violently drawn forwards. It has also been observed to result from the direct pressure of the clavicle backwards, as by the kick of a horse. In one case under my care, the clavicle was dislocated backwards at its sternal end by the wheel of a cab passing across the bone, and thus directly pressing it backwards, fracturing at the same time the second

rib, and separating the first from its cartilage, which was attached to the clavicle by the unruptured costo-clavicular ligament; the traction of the dislocated clavicle on the cartilage by means of the ligament, had probably determined the separation of the cartilage from its rib. It has occurred also as a secondary consequence of curvature of the spine.

The *Signs* are those that usually attend a dislocation of the sternal end of the clavicle—shortening of the shoulder, and deformity about the upper part of the sternum; but, besides these, a special train of symptoms is occasioned, by the pressure of the displaced bone upon the trachea, œsophagus, and vessels of the neck. Difficulty in breathing and swallowing, with congestion of the head giving rise even to a semicomatose state, may be produced to such an extent as to require removal of the end of the bone, as happened in a case of gradual dislocation from deformity of the spine related by Sir A. Cooper, in which the Surgeon was obliged to saw off the dislocated end. In some cases, the end of the bone is thrown upwards as well as backwards; in others, it takes rather a downward direction. In one case only—that described in the preceding paragraph—have I had an opportunity of examining, after death, the condition of the limb in dislocation backwards of the sternal end of the clavicle. In this case, all the ligamentous structures around the end of the bone were torn through, with the exception of the costo-clavicular ligament, which had preserved its attachments unbroken, and had carried away the cartilage of the first rib in the direction of the displaced clavicle.

In the *Treatment* of this dislocation, it is easy to effect the reduction of the bone by making a fulcrum of the fist in the axilla, and then bringing the elbow well to the side, at the same time that an assistant puts his knee between the patient's shoulders and pulls them back; but it is difficult to retain the bone in proper position. To fulfil this object, the figure-of-8 bandage tightly applied to the points of the shoulders, and crossed over a large pad placed in the middle of the back, will give the most efficient support to the part, the elbow being at the same time well fixed to the side and drawn back.

2. The dislocations of the **Outer End of the Clavicle**, or more correctly, the **dislocations of the Acromion** from the clavicle, are more commonly met with than those just described. The most frequent accident of this description is that in which the bone is thrown **upon the Upper Surface of the Acromion**, or **upon the Anterior Part of the Spine of the Scapula**. It is usually caused by violent falls upon the shoulder, and is not an uncommon accident at football. In several cases of this accident which have presented themselves at University College Hospital, there has been no difficulty whatever in the diagnosis. The prominence formed by the displaced bone upon the upper surface of the acromion, the narrowing of the distance from the mesial line to the point of the shoulder, to the extent of from an inch to an inch and a half, the facility of the reduction of the dislocation, and the prominence of the clavicular portion of the trapezius muscle, indicate the nature of the accident (Fig. 266). The *Treatment* of this injury is by no means satisfactory. Reduction may easily be effected by raising the shoulder, drawing it backwards, and carrying it outwards by placing a pad or the hand in the axilla and bringing the elbow well to the side. But, notwithstanding the facility of reduction, there is in many cases a great and, indeed, an unconquerable ten-

dency to the return of the displacement. This is owing partly to the shallowness of the articular surface of the acromion, partly to the tension of the trapezius, by which the acromial end of the bone is drawn upwards and outwards, and in a great degree to the mobility of the shoulder. In every movement of the body or neck there will be found to be a tendency to rising upwards of the end of the dislocated bone, and in the majority of cases this will be insurmountable by any mechanical means that can be employed. It is best limited, if not obviated, by a pad and gutta-percha plate laid on the projecting clavicle, and strapped tightly down by a band passing parallel to the arm and under the flexed fore-arm, this being retained in position by being attached to a strap passed round the opposite axilla. If the displacement continue to be irremediable, a very useful arm will still be left, only somewhat limited in its upward movements.


Fig. 266.—Dislocation of the Clavicle on the Acromion.

The outer end of the clavicle has been dislocated **under the Acromion** by the application of direct violence to the end of the bone. This form of displacement is very rare; several instances have, however, been mentioned in the journals. The diagnosis is easy, simple digital examination pointing out the nature of the accident; and the treatment must be conducted in the same way as that of fractured clavicle.

The acromial end of the clavicle has been known to be displaced **underneath the Coracoid Process.** Here, also, simple examination and the clavicular bandage suffice for diagnosis and treatment.

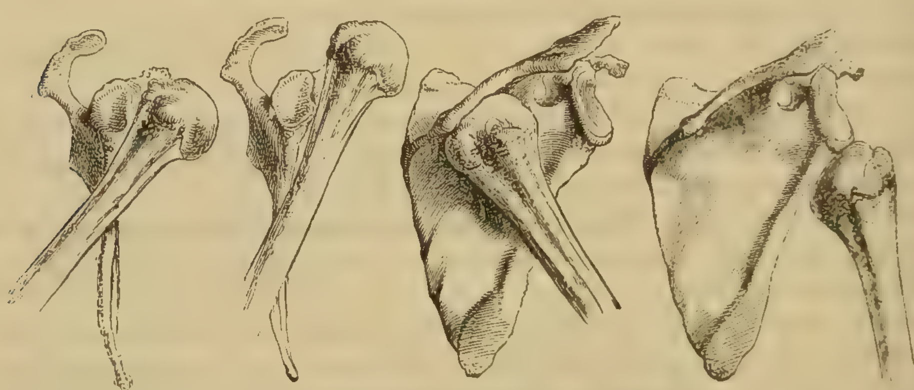
The only instances of **Simultaneous Dislocation of both ends of the Clavicle** with which I am acquainted have been reported by Richerand and Morel Lavallée.

Dislocation of the Scapula.—Under this name has been described a very remarkable kind of displacement of the *Lower Angle and Dorsal Border* of the scapula which is occasionally met with, in consequence of which it projects at a considerable angle from the trunk, giving a winged appearance to the back. This displacement has been attributed to the bone slipping away from under the latissimus dorsi muscle; but it is probable that in the majority of cases at least, it has been really due to paralysis of the serratus magnus. Jacob attributed this to a morbid condition of the muscle itself, but Nélaton regards it as due to paralysis of the long thoracic nerve. Paralysis of the muscle is easily recognized: the projection of the scapula is most marked when the arm is put forwards at right angles to the trunk; if both arms are put in this position it will be found that the patient can push the sound arm forwards about two inches further than the other, the scapular movement being wanting on the paralysed side; in some cases there has been difficulty in raising the arm above the head; expansion of the chest is less perfect on the affected side, and if the patient is thin it can be seen that the digitations of the muscle are feebly marked. In a case of this kind recorded by G. V. Poore, in which the paralysis followed chronic neuritis of the brachial plexus, the result of a strain, the patient gradually recovered under electrical treatment. I have seen some benefit derived in such cases from the endermic

application of strychnine on a blistered surface, and afterwards from support by means of a properly constructed apparatus.

Dislocations of the Shoulder-joint occur far more frequently than those of any other articulation. Their pathology and treatment have been so clearly elucidated by Sir A. Cooper, that there is little left for subsequent writers but to follow the descriptions given by that great Surgeon ; though several of the modern French Surgeons, especially Velpeau, Malgaigne, and Goyrand, have thrown some new light on the subject. The reason of the frequency of these dislocations is to be found in the shallowness of the glenoid cavity, the large size and rounded shape of the head of the humerus, and the weakness of the ligaments ; but, above all, in the extent and force of the movements to which the joint is subjected. These displacements indeed would be much more frequent than they even are, were it not for the protection afforded to the joint by the osseous and ligamentous arch formed by the coracoid process and acromion with their ligaments, the great strength of the capsular muscles and their close connection with the joint, and the support given by the tension of the long head of the biceps; but the principal obstacle to dislocation is the mobility of the scapula, enabling all movements communicated to the hand and arm to react upon that bone.

The **Signs** of dislocation of the shoulder-joint are sufficiently obvious, vary-



DISLOCATIONS OF THE HEAD OF THE HUMERUS.

Fig. 267.—Subcoracoid. Fig. 268.—Subclavicular. Fig. 269.—Subspinous. Fig. 270.—Subglenoid.

ing, however, according to the nature of the injury. In all cases there are seven common signs, viz. :—1, a flattening of the shoulder ; 2, a hollow under the acromion ; 3, an apparent projection of this process, with hollow tension of the deltoid ; 4, the presence of the head of the bone in an abnormal situation ; 5, rigidity ; 6, inability to place the hand on the opposite shoulder while the elbow is made to touch the front of the chest ; and 7, pain about the shoulder.

The shoulder-joint is susceptible of *four* dislocations. Of these, according to Sir A. Cooper, three are complete, and the fourth partial. I think, however, that on examination it will be found that the so-called *partial* dislocation is in reality a complete one. The directions in which the head of the humerus may be thrown are—1, *inwards and slightly downwards* beneath the coracoid process—*Subcoracoid* (Fig. 267) ; 2, *forwards and inwards* beneath the clavicle—*Subclavicular* (Fig. 268) ; 3, *backwards and downwards* under the spine of the scapula—*Subspinous* (Fig. 269) ; 4, *downwards and slightly inwards*

under the glenoid cavity—*Subglenoid* (Fig. 270). Thus three dislocations are more or less inwards, one only being backwards or inwards.

1. **Subcoracoid Dislocation.**—In the case of *incomplete* dislocation reported by Sir A. Cooper, the head of the bone was found to be thrown out of the glenoid cavity, lying under the coracoid process upon the anterior part of the neck of the scapula (Fig. 267) ; the capsular muscles were not torn, but the long head of the biceps had been ruptured. The description given by Sir A. Cooper, and the illustrative plate in his work on *Dislocations*, appear to point to a form of injury of the shoulder-joint which has been specially described by the French surgeons as a variety of the dislocation downwards ; that form of displacement, indeed, which by Boyer has been described as the dislocation "inwards," by Malgaigne as the "subcoracoid" luxation, and by Velpeau as the "subscapular" dislocation ; in which the head of the humerus is placed in front of the neck of the scapula, and underneath the subscapular muscle. In this dislocation the head of the bone, instead of being thrown, as in the subglenoid, downwards and slightly inwards, is thrown inwards either directly or slightly downwards as well. Why Sir A. Cooper described this as a *partial* dislocation, I do not understand ; for not only was there rupture of the capsule and of the long tendon of the biceps, but the woodcut at page 401 of the last edition of his work shows clearly that the head of the bone had formed a new articular cavity for itself in the subscapular fossa, being apparently completely thrown out of the glenoid cavity.

There is here less deformity than in the other luxations, the acromion not forming so distinct a projection (Fig. 271). The limb is usually somewhat lengthened, but at times is actually shortened, the elbow being generally carried backwards and always slightly away from the side ; the head of the bone is placed deeply in the upper and inner part of the axilla, and cannot always be very distinctly felt, owing to its being thickly covered with soft parts, by the coraco-brachialis as well as by the pectorals ; rotation of the arm and elevation of the elbow being usually required in order that it may be detected. There may be pain from the pressure of the head of the bone on the nerves or from stretching, and if the vein be pressed an œdema of the whole limb will occur.

Fig. 271.—Subcoracoid Dislocation of Humerus.

2. In the dislocation **Forwards**, or the **Subclavicular** (Fig. 268), the head of the bone is thrown on the inner side of the coracoid process, lying upon the second and third ribs under the pectoral muscles, and immediately below the clavicle. This dislocation is merely an increased degree of the preceding one, the head of the bone, which at first lies under the coracoid process, being readily drawn inwards, so as to be placed to the inner side of this process under the clavicle. In these cases the capsular muscles are much stretched or torn. In a case recorded by Curling, the infraspinatus and subscapularis muscles were torn away from the tuberosities of the humerus, and the teres minor partially lacerated ; the capsule being completely separated from the neck of the bone, which pressed forcibly upon the axillary vessels and nerves. In three cases which I have had an opportunity of dissecting

and examining after death, the great tuberosity was torn away from the head of the bone, with much laceration of the capsule and extensive extravasation, but the external rotator muscles were not ruptured in two instances; whilst in the third the supraspinatus, the infraspinatus, and the teres minor, were all torn across near the insertions into the humerus. In fact, in these cases it appears to be a question of strength between muscle and bone; either the muscles are torn across, or the great tuberosity, into which they are inserted, is torn away from the shaft of the bone, leaving its attached muscles unruptured.

In this dislocation, the head of the humerus can be felt and seen under the pectoral muscles beneath the clavicle; the arm is shortened, the axis of the limb being directed towards its head, and the elbow is a good deal separated from the side and thrown back.

3. In the dislocation **Backwards**, or the **Subspinous** (Figs. 272, 273), the head of the humerus lies behind the glenoid cavity, and below the spine

Fig. 272.—Dislocation of the right Humerus backwards. (Front View.)

Fig. 273.—Dislocation of the right Humerus backwards. (Back View.)

of the scapula, beneath the infraspinatus and teres minor muscles. Key found the tendon of the subscapularis torn across, together with the internal portion of the capsular ligament; the supraspinatus and the long head of the biceps being stretched, but not ruptured.

When the head of the bone is dislocated below the spine of the scapula, it can be felt and seen there, more especially when the arm is rotated. The axis of the limb is altered, being directed backwards nearly horizontally; the elbow is raised from the side, to which it cannot be approximated, and is carried forwards and somewhat downwards. The accompanying figures, for which I am indebted to Rushton Parker, of Liverpool, show admirably the deformity in this dislocation.

4. In the dislocation **Downwards**, or the **Subglenoid** (Fig. 270), the head of the bone lies in the axilla, resting against the inferior costa of the scapula below the glenoid cavity, and lodged between the subscapular muscle and the long portion of the triceps. In it the tendon of the subscapular muscle is commonly torn near its insertion into the lesser tuberosity of the humerus, and

the capsular ligament is largely lacerated. The supraspinatus muscle may also be torn through, or a portion of the great tuberosity of the humerus detached, and the rest of the capsular muscle put greatly on the stretch. The axillary artery and plexus of nerves are compressed and stretched by the dislocated head of the bone, so that a severe numb pain is commonly experienced in the hand and arm. The compression of the artery is so great, that the circulation through the limb may be completely arrested. This I saw remarkably illustrated in a case of dislocation downwards of the head of the humerus, with a severe lacerated wound of the forearm, dividing the radial and ulnar arteries. So long as the dislocation remained unreduced, no hæmorrhage took place ; but when the head of the bone was replaced, the injured arteries bled freely.

Fig. 274.—Subglenoid Dislocation.

The head of the bone can usually be readily felt in the axilla, at its anterior and under part ; the arm is lengthened to the extent of about an inch, the forearm is usually somewhat bent, and the fingers are often numbed, in consequence of the pressure of the head of the bone on the axillary plexus. The elbow is separated from the trunk and carried somewhat backwards. If the head of the bone cannot be felt in the axilla, its presence there may be ascertained, as Cooper directs, by raising the elbow, when it at once becomes perceptible. On looking at the patient from the front it will be seen that the lower border of the pectoralis major, forming the anterior axillary fold, lies lower than on the opposite side, and if the circumference of the shoulder be measured by a tape passed under the arm, it will be found to be greater on the injured side (Fig. 274).

In a case which occurred to Cleland of Galway, the arm was thrown up so as to reach above the patient's head. This patient was lame and used crutches ; and Cleland supposes that one of the crutches, having slipped, acted as a fulcrum in such a way as to cause the weight of the body in falling to overcome the tendency of the latissimus dorsi and pectoralis major muscles to draw the arm towards the side. Reduction was readily effected.

The dislocation of the humerus, to which the term **Partial** is usually applied, is that which was described by Soden in 1841, in which the long tendon of the biceps is displaced from its groove or ruptured, and the head of the bone is thrown upwards and forwards under the coracoid process, but not out of the glenoid cavity. It is to this form of displacement also that Callaway seems disposed to confine the term *partial*. Le Gros Clark has published an account of a case in which there was partial dislocation of the head of the humerus behind and below the acromion.

In this partial dislocation the *signs* do not appear to be very evident. In Soden's case there was slight flattening of the outer and posterior parts of the joint, and the head of the bone appeared to be drawn higher up in the glenoid cavity than usual. There was great pain induced by any movement of the biceps muscle ; and, on attempting any overhand motions, the head of the bone became locked by the acromion.

Subluxation of the head of the humerus *forwards* occasionally occurs as a

consequence of falls upon the hand or elbow. The injury produces all the signs, but in a minor degree of the subcoracoid dislocations. The head of the humerus lies on the edge of the glenoid cavity. It can easily be replaced, but as readily slips out again, and consequently the accident is very apt to lead to permanent weakness and disability of the shoulder-joint. The treatment consists in its reduction, and the retention of the head of the bone in its place by a carefully moulded leather shoulder-cap, fitted with a truss spring and pad to press the head of the humerus against the glenoid surfaces.

Causes.—Dislocations of the shoulder-joint are in almost all cases the result of falls upon the hand or elbow ; the particular variety of dislocation depending upon the direction of the shock communicated to the arm, and the position of the limb at the time of receiving it. On this account we almost invariably find the displacement in a direction inwards. When a person saves himself in falling with his arms widely stretched out, the head of the bone is driven with all the force of a long lever against the lower and inner portion of the capsule, which, being ruptured in this its weakest part, allows the bone to be thrown upon or to the inside of the inferior costa of the scapula, and thus into the axilla. When the patient falls upon his elbow, the inner part of the joint is still acted on ; but, the leverage not being so great, the head of the bone is thrown upwards or forwards under the clavicle. This dislocation is also often the result of direct violence applied to the shoulder.

The dislocation backwards can take place only if the arm receive the shock at the time when it is stretched across the chest. As this is an unusual position for any injury to be received in, this dislocation is proportionately rare. An obstacle to this displacement may also be found in the great strength of the outer portion of the capsule of the joint, as compared with the inner.

Relative Frequency.—Sir A. Cooper states that the dislocation "into the axilla" is the most frequent form of accident. This opinion is confirmed by that of most English Surgeons. But Malgaigne, and more recently Flower, have expressed the opinion that the subcoracoid is the most common form of this accident. Flower, who has very ably investigated this subject, finds that of forty-one specimens in the different London Museums, thirty-one are undoubtedly *subcoracoid*, and that, of fifty recent cases of which he has cognizance, forty-four were of this form. Next in order of frequency comes the *subglenoid*, and then the *subclavicular*, which is rare. I believe that the subclavicular is, as it were, an exaggerated degree of the subcoracoid ; the continuance of the same force, whether mechanical or muscular, which has thrown or drawn the head of the bone to the inner side of the coracoid process, carrying it upwards and inwards under the centre of the clavicle. The displacement of the head of the bone under the spine of the scapula is so rare that Sir A. Cooper met with two cases only of it ; several cases have occurred at University College Hospital, which were reduced without difficulty.

Diagnosis of Injuries about the Shoulder.—In all cases of injury to the shoulder the patient should be stripped so as to show both shoulders in order that the two sides may be compared. But little is to be learnt from the history, as different forms of injury may arise from apparently similar accidents. The attitude of the patient is often characteristic ; in all dislocations the elbow is separated from the body and the patient leans towards the injured side, so as to allow the limb to hang perpendicularly in its new axis ;

in fractures the elbow is close to the side and the arm hangs powerless. In fractured clavicle the patient inclines the head to the injured side and supports the weight of the arm by holding the elbow in the opposite hand. The power of moving the arm remains to some extent in all dislocations, in impacted fractures of the neck of the humerus, and in fractures of the clavicle between the ligaments ; but it is entirely lost in unimpacted fractures of the neck of the humerus and in fractures of the clavicle about the middle, or accompanied by so much pain that the patient cannot be persuaded to attempt it. Having ascertained this much, the Surgeon should stand behind the patient and place his hands over the shoulders in such a way that the tips of the fore-fingers rest on the sterno-clavicular articulation and the thumbs on the spines of the scapulæ. By comparing the two sterno-clavicular articulations he will at once recognize any dislocation or fracture of the sternal end of the clavicle. He then moves his fingers steadily outwards along the clavicles until he finds the prominence that always marks the acromio-clavicular articulation on each side. In doing this he will at once recognize any fracture of the clavicle, and by comparing the acromio-clavicular articulations would detect any dislocation of that joint. The only injury that would escape detection in this way might be the fracture of the clavicle between the coraco-clavicular ligaments. Tenderness would, however, be found which might draw attention to the seat of injury as the fingers passed over it. The fingers are now to be passed round the acromion carefully comparing it with that on the injured side by which a fracture of its tip will be detected. At the posterior part of the acromion process near its root is always a small tubercle of bone, which has not, so far as I am aware, any definite name. It serves to guide the Surgeon in placing his hands symmetrically on the shoulders, and also is an excellent point from which to measure the length of the arm. Having recognized this tubercle, the fingers may be run along the spine, and any fracture here would be easily detected if not concealed by extravasated blood, as is the case in fracture of the scapula. Having found the two sides symmetrical so far, the Surgeon now places his hand flat on the shoulder on each side, with the fore-fingers on the acromion, and presses the three other fingers firmly in under the process, by which he will at once ascertain whether the head of the bone is in its place or not, the hollow under the acromion being very clearly marked when there is a dislocation. After this the middle finger on each side should be placed on the tip of the coracoid process, which projects sharply forwards about an inch below the clavicle, while the ring finger is pushed into the hollow between the coracoid process and the head of the humerus ; by this means a subcoracoid dislocation is recognized by the approximation of the head of the bone to the process ; the fore-finger, feeling on the inner side of the coracoid process on each side, would at once recognize the difference caused by the presence of the head in a subclavicular dislocation. In a subglenoid dislocation the head of the bone may be felt somewhat indistinctly below and external to the coracoid process. In a subspinous dislocation the prominence of the head will be found just beneath and internal to the process of bone at the back of the acromion before mentioned. If by means of the examination all dislocations of the clavicle, acromion, and humerus, and all fractures of the clavicle are excluded, the Surgeon must next carefully examine the head of the humerus, both from the axilla, and by the finger and thumb grasping the bone through the deltoid. Increased width or a projecting angle of bone may thus

be felt which would indicate an impacted fracture. In fracture of the surgical neck the end of the upper fragment can be recognized both from the axilla and below the tip of the coracoid process. Fracture of the great tuberosity is always complicated with partial or complete dislocation, and would be recognized only by the presence of the signs of dislocation with crepitus and difficulty of keeping the joint in position after reduction. Having thus carefully examined by manipulation we must proceed to *measurement*. This is done by flexing the elbow to a right angle and measuring from the point of bone above mentioned on the root of the acromion to the olecranon. There is only one injury in which there is distinct lengthening—the subglenoid dislocation ; in the subcoracoid dislocation there is usually a very little shortening, but slight lengthening is also said to occur when the head of the bone lies rather lower than usual. In fracture of the surgical neck there is great shortening—an inch or more ; in impacted fracture the shortening is very slight, seldom over half an inch. In injuries of the clavicle there is no shortening. Measurements should next be taken from the tip of the acromion to the middle line in front ; there will be shortening in all fractures of the clavicle (except that between the ligaments) and in all dislocations of the acromion and clavicle. In other injuries the length is unaltered. Finally the arm must be examined by *passive movement*. In all dislocations of the humerus it will be found impossible to place the hand on the opposite shoulder with the elbow touching the chest in front. In unimpacted fractures the movement is accompanied by great pain and crepitus. In fracture of the clavicle between the ligaments the crepitus may be a mere click felt on raising the arm over the head. If after thorough examination nothing can be detected, and yet the patient is suffering pain with inability to move the joint, the deltoid may be examined, and a tender spot may be found. If at the same time all passive movement is free and unaccompanied by pain, unless the muscle is stretched, while voluntary contraction of the muscle is painful, the case is probably one of bruise of the deltoid with possibly a laceration of some of its fibres. If there is slight fulness about the shoulder, with pain on passive or active movement, the case is probably one of inflammation of the joint following a bruise.

At a more remote period from the injury, intense pain while at rest, aggravated by movement, may be due to neuritis of the brachial plexus following a strain, which may be recognized by the symptoms described in the chapter on injuries of nerves.

Paralysis of the deltoid from a blow or from injury of the circumflex nerve may simulate a dislocation, the shoulder being flattened and the acromion projecting : but here the mobility of the joint, and the presence of the head of the bone in the glenoid cavity, establish the absence of dislocation.

The **Reduction** of a dislocated humerus may be conducted on four different plans :—*by the heel in the axilla ; by the knee ;* or *by drawing the arm upwards ;* and *by manipulation*. Whichever plan is adopted, the patient should, if strong, be put under the influence of chloroform ; when his muscles are paralysed by this agent, but little force is required to effect the reduction, the Surgeon's unaided strength usually sufficing for this purpose. If more power, however, should be required than he can exercise, extension may be made by assistants drawing upon a towel properly fixed round the lower end of the humerus, or else by the pulleys attached to the same part of the limb.

1. The reduction of the dislocation *by the heel in the axilla* is a most effi-

cient procedure in ordinary cases. In adopting this plan, the patient is laid upon his back upon a low bed or couch, or even on the ground; the Surgeon,

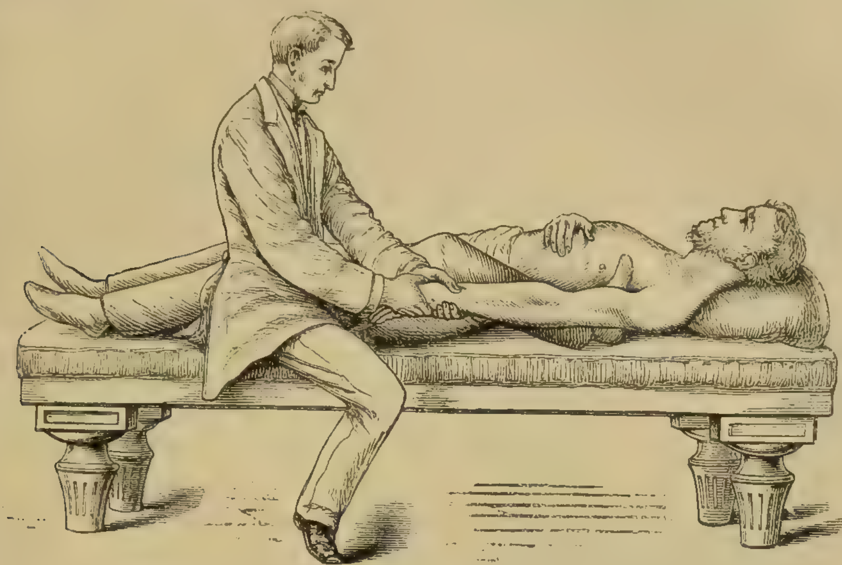


Fig. 275.—Reduction of a Dislocated Shoulder-joint by the Heel in the Axilla.

seating himself upon the edge of this on the same side as the dislocated arm, takes the limb by the wrist, and, fixing one foot firmly upon the ground, places the other, covered merely with the stocking, well up into the axilla, so that the heel may press against the lower border of the scapula, and the foot act upon the humerus (Fig. 275). He then draws the limb steadily downwards, and, when it is disengaged to a sufficient extent, brings the hand across the front of the patient, the foot acting as a fulcrum, by which the head of the bone may be reduced by being pushed upwards and outwards. This mode of reduction is especially serviceable in ordinary dislocations into the axilla, and in those under the clavicle. In the latter, however, it will be necessary to draw the arm more obliquely downwards and backwards, and to press the foot somewhat forwards upon the head of the bone, after it has been disengaged by being brought below the coracoid process.

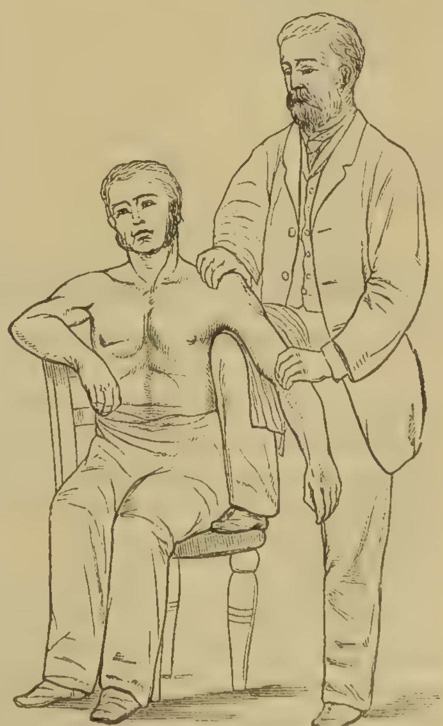


Fig. 276.—Reduction of a Dislocation of the Humerus by the Knee in the Axilla.

2. The reduction *by the knee in the axilla* (Fig. 276) is precisely the same in principle as the last, though not by any means so good a plan, the knee being too large, and not following the movements of the humerus so readily as the foot. In effecting the reduction by this means, the patient is seated on a chair; and the Surgeon, standing by his side and resting one foot upon the chair, places his knee in the patient's axilla. He then seizes the patient's arm above the

elbow with his right hand, and, steadying the acromion with his left, draws the limb well away from the body and then depresses it across the knee: the head of the bone is thus reduced.

3. Another mode of reduction which will be found to succeed in almost all cases of subglenoid and subcoracoid dislocation is to place the patient upon a low chair or couch, and to raise the arm *perpendicularly by the side of the head*, at the same time fixing the acromion and making gentle traction upwards. The Surgeon should stand behind the patient, and in many cases so little force is required, that he can take the arm in one hand and steady the acromion with the other. Should more force be necessary, an assistant may steady the shoulder, or the Surgeon may use his foot (Fig. 277). When the bone is felt

Fig. 277.—Reduction of Dislocation of the Humerus by the perpendicular method.

to slip in, the arm must be brought down to the side, while the head of the bone is held outwards by the hand in the axilla. In this mode of reduction the untorn part of the capsule is relaxed to the greatest possible extent, as also is the deltoid, which is one of the most powerful of the muscles concerned in keeping up the displacement.

4. Reduction by the following manipulation has been recommended by Kocher in all cases of subcoracoid dislocation:—Seat the patient in a chair, and stand by his side; then flex his elbow to a right angle and press it inwards as far as possible towards the chest; then, holding the elbow in one hand, and using the forearm as a lever, rotate gently and steadily outwards till a distinct sense of resistance is felt; the elbow must be now brought forwards. or in other words the arm must be raised, with a slight inclination inwards: finally, the hand is placed on the opposite shoulder, by which a movement of rotation inwards is impressed on the humerus. This method, which was the result of the examination of dislocations produced on the dead body, is so

devised as to relax the tight bands of the capsule and to make the opening gape. This method has, in Kocher's hands, been very successful even with old dislocations: thus, he has successfully reduced one at three weeks, two at five weeks, three at seven weeks, four at three months, and two at four months. In one case, an old woman of 70, with an unreduced dislocation eight weeks old, fracture of the arm took place, and reduction became impossible. This method has been found extremely successful with recent dislocations at University College Hospital.

If these simpler methods fail, or the dislocation be of old standing, it may be necessary to have recourse to the *pulleys* in order to effect reduction. In applying these the scapula must be firmly fixed, the counter-extension being made by passing the patient's arm through a slit in the middle of a jack-towel, which should be fixed firmly to a hook or staple in the wall. The extending force may then be applied immediately above the elbow; and traction being made slowly and steadily in the direction of the axis of the limb. The head of the bone should be directed to the glenoid cavity by the pressure of the Surgeon's hands, so soon as it has come on a level with it. In this way dislocations of the humerus of many weeks' or even months' standing have been successfully reduced; but in employing these powerful means, especially under the influence of chloroform, the Surgeon should always bear in mind that, unless care be taken, serious mischief, even laceration of the axillary artery, may result (pp. 634, 635).

After a dislocation of the humerus has been reduced, the limb should be firmly fixed to the side for at least two weeks. It may then be put in a sling for another fortnight: and, at the end of a month, passive motion, with friction, may be employed. If inflammation occur about the joint, recourse may be had to leeches and evaporating lotions.

After reduction, there is a tendency for the head of the bone to be drawn upwards and outwards under and against the acromion, owing evidently to the deltoid and coraco-brachialis muscles not being counterbalanced in their actions by those that have been separated from the head of the bone.

Compound Dislocation of the Head of the Humerus is a rare accident. I have, however, seen two cases of it, and in two directions: downwards—*Subglenoid*, and inwards—*Subcoracoid*. In both cases reduction was effected, and the patients did well. In it, even though the injury be extensive, it is better not to amputate if the axillary vessels and nerves be uninjured. The limb may be saved by reducing the bone at once; and the wound should be treated according to the rules laid down in the chapter on wounds of joints. If the axillary artery be ruptured, either completely or through its inner and middle coats, obstruction to the arterial circulation of the arm will ensue, and amputation must be performed through the articulation.

Complications.—A *Simple Dislocation of the Head of the Humerus, with Rupture of the Axillary Artery* and the formation of a diffused axillary aneurism, is serious but fortunately rare. The treatment will be discussed when treating of rupture of the artery during attempted reduction of an old dislocation.

A very serious accident, and apparently difficult to treat, consists in the complication of a *Dislocation of the Humerus with Fracture through the Epiphysis* of the displaced bone. A case of this kind, to which I was called, is described at page 637.

When the dislocation is complicated with a *Fracture of the Shaft of the Bone*, it should be reduced at once by putting the fracture up very firmly, and then attempting the reduction by one of the usual methods. In the cases to which I have already referred (p. 637), I succeeded without difficulty by means of the heel in the axilla. The fracture must then be treated by lateral splints.

Congenital Dislocations of the Shoulder-joint have attracted much attention. R. W. Smith has ascertained, by *post mortem* examination, the existence of two varieties of this condition—the *Subcoracoid* and *Subacromial* luxations. In these there is wasting of the muscles of the shoulder and arm, the motions of which are extremely limited, whilst those of the scapula are preternaturally great. The condition of the bones is also remarkable. In a case of congenital subacromial luxation of both shoulders there was no trace of a glenoid cavity ; but a well-formed socket existed on the outer side of the neck of the scapula, receiving the head of the humerus, which was small and distorted. These dislocations, though existing from birth, usually become more marked as age advances, but are necessarily irremediable, in consequence of the malformation of the osseous structures and the wasting of the muscles.

Old Unreduced Dislocations of the Head of the Humerus are not unfrequently met with. In the majority of these cases there is a considerable amount of pain and immobility about the shoulder at first ; but after a time the head of the humerus forms a new bed for itself, and the movements of the arm become freer and less painful, so that eventually a limb, useful for all except the overhead movements, results.

In cases of old dislocation of the head of the humerus, the question as to the advisability of attempting reduction always presents itself to the Surgeon. As a general rule this should always be attempted under chloroform, in accordance with the principles laid down at p. 632, if only a few weeks have elapsed from the time of the accident, and then it will usually be attended with success. Reduction has been effected in many cases at much later periods than this ; by Brodhurst, after twenty-five weeks had elapsed ; by Smith (U.S.), after six, seven, eight, nine, and ten months ; by Malgaigne, after eight months ; by Caron du Pillard, after six months ; and by Sédillot, after a year. By the use of the subcutaneous division of muscles, &c., Dieffenbach is said to have succeeded in reducing a dislocation of the shoulder after it had existed two years. In many cases, however, at a much earlier period than these, the Surgeon will fail, notwithstanding the most persevering attempts at reduction ; and in others again, certain accidents have occurred, which every Surgeon should bear in mind, so as to render him cautious in his proceedings.

The *Accidents* that have occurred in attempts at reducing old-standing dislocations of the head of the humerus are such as may arise either from the employment of an undue amount of force, from the separation of the head of the humerus from the adhesions that it has contracted in its new situation, or from pathological changes in the limb itself. Among the first are laceration and bruising of the skin, subcutaneous areolar tissue, and muscles, with extravasation of blood : amongst the latter are fracture of the humerus, laceration of the axillary vessels and nerves, and avulsion of the limb.

Fracture of the humerus has occurred in the practice of many Surgeons of

eminence. It has happened to Petit, Pott, Larrey, Bérard, Denonvilliers, and others. The surgical neck of the bone appears to have usually given way; and the accident has not occurred so much from forcible extension, as in carrying the arm across the chest so as to tilt the head of the bone into its place, when the shaft becomes exposed to fracture by pressure in a transverse direction. Such an accident necessarily prevents all further attempt at reduction.

Fracture of the ribs, by the pressure exercised against the wall of the chest, is supposed to have occurred in some cases.

The *extravasation* of a large quantity of blood into the areolar tissue of the axilla has occasionally occurred, without any evidence of the rupture of one of the main vessels. In these cases the swelling has gradually subsided under the employment of ordinary treatment, by rest and evaporating lotions.

More serious by far than this is the *rupture of one of the large blood-vessels* in the axilla. This may happen either from the pressure of the Surgeon's heel—as in a case reported by Hamilton, in which an attempt was made to reduce a dislocation of old standing by this means, the Surgeon unfortunately forgetting to remove his boot, and thus contusing and lacerating the artery—or from the humerus having become adherent to the vessel, and lacerating it when torn away. The instances on record of laceration of the axillary artery, and the consequent formation of a diffuse *traumatic aneurism* in the axilla, in the reduction of old dislocations, are so numerous—there being at least twelve cases in the records of surgery—as to act as a warning to the Surgeon not to employ too much force.

In the great majority of these cases—in at least ten out of the twelve—the diffused traumatic aneurism appeared immediately after the employment of forcible and long-continued extension. In the remaining two instances, the aneurismal tumour did not appear until after the lapse of some time. In Dupuytren's case a woman, 60 years of age, had reduced a dislocation into the axilla of six weeks' standing. Two or three months after this, a tumour appeared in the armpit. This was mistaken for an abscess, and opened; arterial bleeding ensued, and the patient died on the eighth day, from secondary hæmorrhage. In Nélaton's case the patient, also an old woman, had a subglenoid dislocation which was easily reduced. But an aneurism appeared in the axilla, which, three months after the reduction, compelled that distinguished Surgeon to tie the subclavian. Both these aneurisms were probably circumscribed.

Dupuytren's case was not the only one in which the fatal mistake was committed of opening the aneurism in the axilla—the same was done by Pelletan, who mistook the tumour for an emphysema; the result being of necessity fatal. In cases reported by Verduc, Petit, Platner, and Leudet, the aneurism was allowed to run its course unchecked by efficient surgical treatment, and in every instance proved fatal by the sac giving way, and secondary hæmorrhage ensuing. Sir C. Bell records a case that occurred at the Newcastle Infirmary, in which the pectoral muscles as well as the artery were torn, and immediate amputation became necessary. In four cases the subclavian artery has been ligatured. All these happened in America; two to Gibson, one to Blackman of Cincinnati, and one to Warren. Three of them proved fatal by secondary hæmorrhage, Warren's being the only one in which recovery took place.

What *Treatment* should be adopted in this distressing accident? If the

aneurism be left to itself, or be treated by inefficient means, it must necessarily prove fatal by its rupture or sloughing and secondary hæmorrhage. The ligature of the subclavian is not very promising, as a fatal result occurred in three out of the four cases in which it has been tried for diffuse aneurism, Nélaton's case having been circumscribed. In these circumstances, it appears to me that it would be wiser to apply to these cases the usual principle of treatment that is adopted in cases of diffused axillary aneurism from other causes; viz., to compress the subclavian, lay open the sac, turn out coagula, and tie the torn artery at the seat of injury.

In one case, the dislocation being of twenty days' standing, and the patient a female 26 years old, Froriep states that reduction was followed by sudden and extensive tumefaction of the axilla, syncope, and death in an hour and a half. A *post mortem* examination disclosed *laceration of the axillary vein*. No mention is made of any internal injury to account for death.

Injury to the *axillary nerves* during reduction leading to paralysis of the arm has also been described. A case of this kind is mentioned by Billroth as having occurred in a patient under his care at Zurich. The dislocation was of nine months' standing, and had been attended by partial paralysis of the arm and some muscular atrophy. The reduction was followed by total paralysis, which Billroth attributes to laceration of the axillary nerves in consequence of their having become adherent to the bone. In the case recorded by Flaubert, already alluded to, four of the nerves were torn from their attachments to the cord.

Besides these accidents, other evil consequences have occasionally followed prolonged attempts at reducing old dislocations of the humerus, such as sudden death from *syncope*, and *exhaustion*. Guérin's remarkable case of *avulsion of the limb* at the elbow in a woman 63 years of age, in an attempt to restore a dislocated humerus three months after the luxation had occurred, is an instance of an accident that is as yet unique in the records of surgery. In this case no undue amount of force seems to have been used, but the tissues of the limb had become softened—partly probably from disuse, partly from senile changes.

In the event of the Surgeon being unsuccessful in his attempts at reduction, he must endeavour, by means of frictions and passive motion, to restore, as far as practicable, the utility of the limb. In some of these cases of old reduced dislocation I have succeeded in very materially improving its condition by putting the patient under the influence of chloroform, and moving the limb freely to and fro so as to loosen, stretch, and break up the adhesions about the head of the bone; and it is in this way that attempts at reduction, even though unsuccessful in replacing the head of the bone, are often of great use in improving the mobility of the limb.

In cases of old standing, where symptoms of pressure on the large vessels and nerves are present, and where there is danger of their being injured in the attempt at reduction, Billroth recommends excision of the head of the bone. This has been done successfully by Langenbeck in a case of paralysis from pressure.

Dislocations of the Elbow are extremely common. According to Krönlein they form 27 per cent. of all dislocations. They occur with special frequency in children; thus, out of 94 cases of dislocation of both bones backwards collected by Krönlein, 22 occurred in children under 10 years of age,

and 44 between 10 and 20. Dislocations of the elbow are most commonly caused by indirect violence, chiefly falls on the hand complicated by a twist of the joint. In other cases they may be the result of direct violence, in consequence of which much swelling speedily sets in, their signs are obscured, and the diagnosis is rendered proportionately difficult; more especially when the dislocation happens to be complicated with fracture of the articular ends of the bones. In these cases, indeed, it is only by an accurate acquaintance with the normal relations of the osseous points, and by a comparison between those of opposite sides, that the Surgeon can detect the true nature of the injury.

The **Varieties** of dislocation of the elbow-joint are very numerous, either both bones of the fore-arm or only one being displaced.

1. **Both Bones.**—The most common dislocation is that in which both bones are thrown *Backwards*, without fracture of the coronoid process. In rare cases, however, this process may be broken off. This injury is readily recognized by the projection backwards of the olecranon, carrying with it the tendon of the triceps. The articular end of the humerus also can be felt projecting in front of the elbow. When the coronoid process is not broken off, it is fixed against the posterior surface of the humerus, the fore-arm being immovably placed in its new position. In the rare cases in which this process is fractured, there is great mobility about the joint, and crepitation may be felt as the arm is drawn forwards.

Dislocation of both bones **Forwards** can scarcely occur without fracture of the olecranon. Rare as this accident must be, there are at least five cases on record by Colston, Lana, Delpech, Canton, Forbes of Philadelphia, and Date, in which the bones have been so displaced without this process being broken. In this injury the elongation of the forearm, the projection of the condyles of the humerus, the presence of the sigmoid notch in front of the arm, and the depression of the posterior surface of this bone, render the diagnosis sufficiently easy. In one case at University College Hospital, the injury was produced by the patient, a man 20 years of age, slipping on the pavement and falling on his elbow. In this instance the elbow was much bent; it could be brought to a right angle, and straightened considerably. The fore-arm was three quarters of an inch longer than its fellow. The condyles of the humerus were on a level with the olecranon; the tendon of the triceps was very tight, and the sigmoid notch could be plainly felt on the fore part of the arm. The head of the radius could also be felt in front of the humerus. In the case recorded in the *Lancet*, 1872, by Date of Crewkerne, the dislocation was forwards and outwards, so that the head of the radius lay outside the external condyle. At the same time, the epiphysis at the inner condyle was separated. When the olecranon is broken off, there is elongation of the fore-arm and great mobility, but the detached fragment can be felt behind the humerus.

The **Lateral** dislocation of the bones of the forearm is almost invariably incomplete; either the head of the radius hitching against the internal condyle, or the ulna coming into contact with the external one. Complete lateral dislocation of the bones of the forearm is excessively rare: the only instance with which I am acquainted is a luxation outwards, reported by Nélaton, of which he has given a woodcut.

The ulna or radius alone may be displaced; and in some cases, both bones are dislocated, but in opposite directions.

2. **Ulna.**—The only dislocation to which the ulna alone is subject is that in a direction **Backwards.** Although this displacement may occur in an uncomplicated form, it is more frequently associated with more or less dislocation of the head of the radius. When it occurs, it may be recognized by the projection of the olecranon backwards, and by the head of the radius being felt in its normal situation, or nearly so, during the movements of pronation and supination. In some extremely rare cases the coronoid process is fractured at the same time, causing ready disappearance and recurrence of the dislocation, with crepitus.

3. **Radius.**—The radius alone may be dislocated *forwards*, *backwards*, or *outwards*. The dislocation **Forwards** is by far the most common. In the many instances of it that I have seen, it has resulted from a fall on the palm

Fig. 278.—Dislocation of the Radius forwards: Limit of Power of Bending the Arm.

Fig. 279.—Dislocation of the Radius forwards: Deformity of Outer Side of the Arm when Extended.

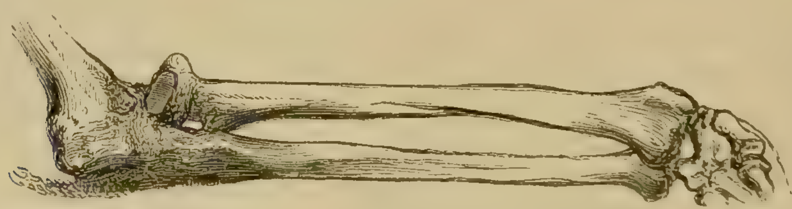


Fig. 280.—Position of the Bones in an old Unreduced Dislocation of the Radius forwards.

of the hand, by which the lower end of the radius is driven backwards, while the upper end is tilted forwards with the whole force of the leverage of the bone, and in this way, rupturing the annular ligament, is thrown against the external condyle. The signs of this displacement are the following. The forearm is slightly flexed, and in a mid state between pronation and supination; any attempt at completing the latter position occasions great pain, as does also the endeavour to straighten the arm. The elbow can be bent only to an obtuse angle, in consequence of the head of the radius being suddenly brought up against the lower end of the humerus, against which it strikes with a sudden shock (Figs. 278, 280). On rotating the radius much pain is experienced,

and the head of the bone can be felt to roll on the fore part of the humerus, the external condyle of which projects unnaturally, with a distinct hollow beneath it where the head of the radius should be. The hand and arm can be fully pronated, but cannot be supinated more than half way. The whole of the outer side of the arm is deformed, being carried somewhat upwards (Fig. 279). The rupture of the annular ligament in this dislocation makes it very difficult to keep the head of the radius properly fixed, so as to prevent a recurrence of the displacement.

In some cases, and indeed not unfrequently, there is **incomplete dislocation of the radius forwards,** arising either from falls upon the hand, or from violent twists of the forearm. In these we have the preceding signs, though less marked. The most characteristic symptom, however, is the patient's inability to flex the forearm upon the arm. This he can never do to a greater extent than to bring the elbow to a right angle (Fig. 278). On being told to touch the tip of his shoulder with his fore-finger, he will find it impossible to do so.

The dislocation of the radius **Backwards** is extremely rare ; it may always be recognized by the head of that bone being felt subcutaneously, behind the external condyle ; the movements of the elbow, and of the radius especially, being at the same time very limited and painful.

Dislocation of the radius **Outwards** is of more frequent occurrence than the last injury, the head of the bone being thrown on the outer side of the external condyle, where it is felt under the skin, rolling as the hand is moved. The natural motions of the joint are of course greatly interfered with.

The radius and ulna are sometimes displaced in **Opposite Directions**, the ulna being thrown *backwards*, and the radius *forwards*. This injury, of which I have seen two instances at the hospital, usually results from heavy falls upon the hand, with a wrench of the limb at the same time, as when a person is thrown out of a carriage and alights upon his hands, in consequence of which the bones are twisted and displaced in opposite directions. The deformity is of course great, but is readily recognized by the combination of the characters of the two forms of displacement, provided an examination be made before the swelling, which rapidly sets in, has come on.

Complications.—Dislocations of the elbow-joint are very frequently complicated with fracture of one or other condyle of the humerus, of the olecranon, and—more rarely, as we have already seen in displacement of the ulna—of the coronoid process. In these complicated injuries an exact diagnosis is often extremely difficult, owing to the laxity and mobility of the parts, and to the great tumefaction that accompanies accidents of this description.

Diagnosis.—For the diagnosis of these various injuries a good knowledge of the relative bearing of the different osseous points is essential, but an accurate comparison of the injured with the sound limb is equally important. Dislocation of both bones backwards most nearly resembles separation of the lower epiphysis of the humerus, but the distinction can usually be easily made by attention to the rules laid down on page 572.

The mode of **Reduction** in dislocations of the elbow-joint varies according as the ulna is displaced or not. When the ulna is dislocated, in whatever direction it may be thrown, and whether the radius be displaced at the same time or not, the great obstacle to reduction is the hitching of the processes of the bone against the articular end of the humerus. If either the olecranon or

coronoid process be fractured, this entanglement cannot take place, and the joint then readily slips into its position, though it is very difficult to maintain it there. The reduction of the displaced ulna, when uncomplicated by fracture, may always be effected, as Sir A. Cooper has recommended, by bending the arm over the knee. The patient being seated on a chair, the Surgeon rests one foot upon the seat, and, placing the knee in the bend of the injured elbow, grasps the forearm with both hands (Fig. 281); fixing the arm, he presses the knee firmly against the inner aspect of the forearm, so as to disengage the ulna from the lower end of the humerus, and at the same time he bends or pushes the forearm into proper position, into which, indeed, it has a tendency to return by the action of its own muscles, so soon as the opposing osseous surfaces are separated.

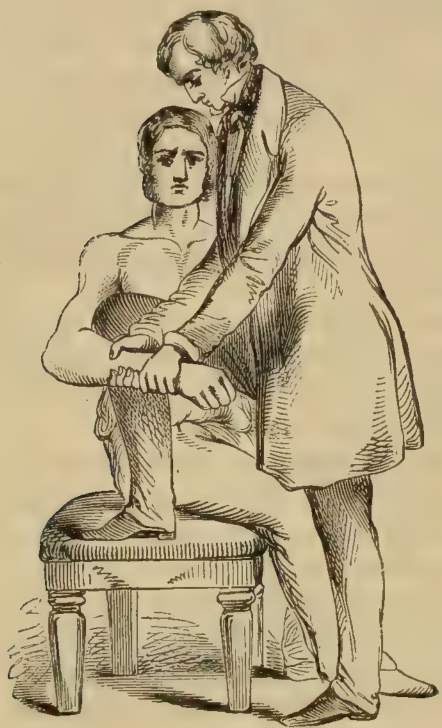


Fig. 281.—Dislocation of the Ulna: Reduction.

In dislocations of the radius, this movement across the knee is not necessary. All that is required is to fix the upper arm, and then, employing extension from the wrist, to straighten the arm well; when, by bending the elbow at right angles, the head of the radius may be pressed into a proper position.

After reduction has been effected, the limb should be firmly put up in lateral angular splints, the hand being kept semi-prone. If the radius have been displaced, a pad should be applied over its head, so as to prevent a return of the displacement, which is very apt to occur when the orbicular ligament is torn. In the case of dislocation of the radius *forwards*, however, reduction is best maintained by placing the arm in the extended position, and applying a straight splint, well padded, along the palmar aspect of the limb. The inflammation which usually results must be combated by the application of evaporating lotions. When it has subsided, passive motion may be commenced, and frictions and douches employed, so as to remove the stiffness that is apt to be left about the joint.

In those cases in which the dislocation is complicated with fracture of some part of the articular ends, and in which the diagnosis of the precise nature of the injury, owing to the swelling or other causes, has not been very clearly made out, the joint should be placed in as good a position as possible, by a process of traction, flexion, and moulding, so as to bring the osseous points into proper bearing with one another; the angular splints must then be applied and local antiphlogistic treatment employed. At the end of a month or five weeks passive motion may be commenced, lest permanent rigidity, which is very apt to supervene, come on.

Compound Dislocations of the Elbow are always very serious injuries, although by the employment of a rigorous antiseptic treatment their gravity may be much lessened. By these means a useful joint may usually be saved

when the soft parts are not too extensively lacerated, without any operative interference. In other cases the Surgeon may often have to decide between resection of the articular ends and amputation of the arm. Should the soft structures be extensively contused and torn, the brachial artery or the median nerve injured, and the bones fractured as well as dislocated, amputation will be the safer course. In determining on the line of practice, however, the Surgeon will be guided by the considerations stated at p. 575, in reference to compound fracture of this joint. In some instances recovery has taken place with a very useful limb, even after severe compound dislocation of the elbow-joint, complicated with rupture of the brachial artery.

Old-standing Dislocations of the Elbow are reduced with much difficulty in all cases in which the ulna is completely displaced ; this is owing rather to the interlocking of the irregular articular surfaces and to the formation of adhesions in the torn capsule and around the displaced bones, than to muscular contraction. The tendon of the triceps, and even that of the biceps, has been divided in some of these cases of old-standing dislocation of the elbow, in order to facilitate reduction. In those instances in which I have done this operation or seen it adopted, but little, if any, good has resulted ; and I have known troublesome sloughing to ensue. As a general rule, I believe that it will be found extremely difficult, even under anæsthesia and with the aid of the pulleys, to reduce an ulna that has been completely dislocated for more than a month. When the ulna is only partially dislocated, even though the radius be completely displaced, reduction may be effected without much difficulty at a very much later period—it is said, as late as two years after the accident ; but here the difficulty is not to effect but to maintain the reduction and keep the bone in position, as it has a constant tendency to slip forwards and outwards. Provided a dislocated elbow can be so far reduced as to allow the forearm to be bent at a right angle, a useful arm will be left.

DISLOCATIONS OF THE WRIST are of rare occurrence ; so much so, that their existence has been denied by Dupuytren and other modern Surgeons of great experience. Although there can be no doubt that fractures of the lower end of the radius, more especially of an impacted character, have often been mistaken for these displacements, yet there can be now no question that they do occasionally, though rarely, occur. Any doubt that may formerly have existed upon this point, in consequence of the want of *post mortem* examinations, has been in recent years cleared up by the dissections of cases that have been made by Marjolin and Voillermier. The observations of these Surgeons, together with those previously made by Sir A. Cooper, tend to show that dislocation of the **Hand and Carpus** from the radius may take place either *backwards* or *forwards*.

These accidents are occasioned either by falls on the palm, or by the hand being forcibly bent forwards. In falls on the palm the hand may be thrown forwards under the bones of the forearm, lying on their palmar aspect. In forcible bending of the hand forwards there may be displacement of it and the carpus backwards on the dorsal aspect of the radius and ulna.

In the **Dislocation of the Hand and Carpus Backwards**—the **Dorsal** displacement—there will be shortening of the length of the limb below the elbow, with a large dorsal prominence occasioned by the carpus overlapping the lower end of the radius, which bone will be felt and seen as a projection on the palmar side. In the other variety of radio-carpal dislocation, the

Hand and Carpus are thrown Forwards under the radius and ulna on their **Palmar** aspect. This dislocation is illustrated in the accompanying figure, taken from a cast sent to me by Cadge of Norwich (Fig. 282). In it the projection of the styloid process of the ulna and the lower end of the radius form a concave line on the dorsal aspect, overlapping the carpus, which lies on the palmar side of the radius.

The *Diagnosis* of these injuries has to be made from sprains of the wrist, from simple and from impacted fractures of the radius. From sprains of the wrist, the great and prominent deformity will at once enable the Surgeon to distinguish a dislocation. From simple fracture of the lower end of the radius, the peculiar deformity, and the absence of crepitus, will afford ready means of diagnosis. It is from the impacted fracture of the lower epiphysis of the radius that it is most difficult to distinguish a dislocation. In the dislocation, however, the general laxity of the wrist-joint, the greater readiness with which the deformity is removed, the peculiar and abrupt swelling, and the absence of obliquity of the hand towards the radial side, will enable the Surgeon to distinguish the true nature of the injury.

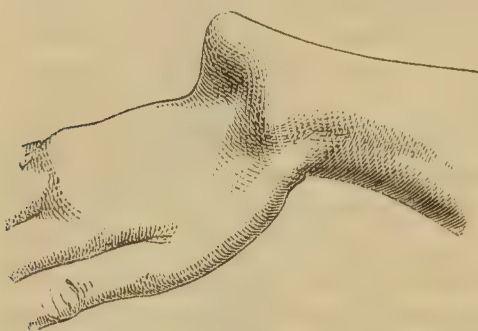


Fig. 282.—Dislocation of the Hand and Carpus forwards.

The *Treatment* of these cases is simple, and in accordance with general principles. Reduction, which is readily effected, must be maintained by the application of antero-posterior splints of sufficient length to take in the hand.

Compound Dislocation of the Wrist, without fracture of the bones of the fore-arm, is a rare accident. In one such case which came under my care at the Hospital, in consequence of injury inflicted on the arm by machinery, the hand was thrown forwards, the radius projecting backwards, and the soft structures on the palmar aspect of the joint were so extensively torn through as to necessitate amputation. The *Treatment* of such a case will depend on the amount of injury done to the soft parts. If these be not very extensively injured, an attempt may be made to save the limb ; but if they be widely torn through, the arteries and nerves lacerated, and the tendons perhaps hanging out, amputation will be required ; this occurred, and the operation was performed, in the case to which I have just referred. This will be rendered more imperative if the bones of the fore-arm be comminuted as well.

Congenital Dislocation of the Wrist may take place either forwards or backwards. The limb is in either case greatly deformed. The bones are shortened and altered in shape, more especially the lower end of the radius. The muscles are also shortened, the extensor tendons forming a sharp angle as they pass over the carpus.

Dislocations of Single Bones of the Carpus are by no means frequent. The bone that is most commonly displaced is the **Os Magnum**. This accident usually happens from falls, in which the hand is violently bent forwards, in consequence of which this bone starts out from its articulations, projecting as a round hard tumour on the back of the wrist opposite to the metacarpal bone of the middle finger. It may be readily reduced by being pressed upon while at

the same time the hand is extended. There is, however, a great tendency for this bone to slip out again, leaving considerable weakness of the joint; so much so, that in two cases recorded by Sir A. Cooper, the patients found it necessary to wear artificial supports.

The **Pisiform Bone** is occasionally dislocated upwards. In a case under my care, it was displaced by an effort to lift a heavy weight, and drawn up the arm to a distance of nearly an inch by the flexor carpi ulnaris.

A case some time ago occurred to me, at the Hospital, in which the **Semilunar Bone** was dislocated. The patient had fallen from a height, injuring his spine, and doubling his right hand under him. On examining the wrist, a small hard tumour was felt projecting on its dorsal aspect; it readily disappeared on extending the hand and employing firm pressure, but started up again so soon as the wrist was forcibly flexed. It was evident that this bone belonged to the first row of the carpus, articulating with the radius; and from its size, its position towards the radial side of the carpus, and its shape, which could be very distinctly made out through the integuments, there could be little doubt that it was the semilunar bone. Taaffe, of Brighton, has related a case in which the semilunar bone was dislocated anteriorly, so that it projected upwards and forwards between the radius and ulna.

Dislocations of the Metacarpal Bones.—The **Metacarpal Bones** may possibly, though very rarely, be dislocated from the carpus. This accident happens usually to a single metacarpal bone; which, in consequence of some extreme degree of violence, is forced out of its bed and is thrown backwards on the carpus. Most frequently, this accident is the result of injury and shattering of the hand by gun-barrel or powder-flask explosions; and in such cases the metacarpal bone of the **Thumb** is the one that commonly suffers, the dislocation being also usually compound, and complicated with fracture of the bones and extensive palmar laceration. Dislocation of the metacarpal bone of the thumb, however, is rare, though the articulation between this bone and the trapezium appears at first not to be of a character to resist much external violence. This is probably owing in a great measure to the powerful muscles by which the bone is supported in all cases in which the force is applied upon its palmar aspect, as it most frequently is, as well as to the little leverage offered by so short a bone. Luxation, however, of the metacarpal bone of the thumb has been observed to take place *forwards* as well as *backwards*, the latter being the most common. The *Reduction* is in general easy, extension being made from the thumb by means of a piece of tape applied round the first phalanx.

Next to the metacarpal bone of the thumb, those of the **Index** and **Middle Fingers** are most liable to dislocation backwards: sometimes complete, at others incomplete.

I am not acquainted with any case on record in which *all* the metacarpal bones have been dislocated from the carpus. The annexed engraving (Fig. 283) is from a cast in University College Museum, taken from a patient in the Hospital, in whom I believe that this accident must have occurred; the hand being thrown forwards and shortened, and the carpal bones forming a rounded and *convex* prominence on the dorsum of the metacarpus. The convex appearance of this corresponds with the outline of the carpal bones, and differs so very remarkably from the concave aspect of the lower end of the radius and ulna, as seen in the radio-carpal dislocation (Fig. 282), that I

think there can be little doubt as to the nature of the injury sustained by the patient.

The *Treatment* of such cases will be the same as that for ordinary dislocations of the carpal bones ; splints of sufficient length to take in the hand being applied, after reduction, in order to maintain the parts in position.

Dislocations of the Metacarpo-Phalangeal Articulations are by no means of common occurrence. They are usually produced by falls on the hand, and are met with at all ages ; most commonly in the young adult, but sometimes at an earlier age. I have seen this accident in a child four years old. Most frequently the **Proximal Phalanx of the Thumb** is the bone that is dislocated, being thrown *backwards* on the metacarpal bone (Fig. 284) in such

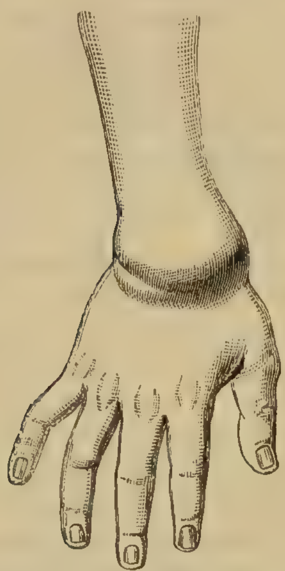


Fig. 283.—Dislocation of the Metacarpus, forwards, from the Carpus.

Fig. 284.—Dislocation, backwards, of the Proximal Phalanx of the Thumb.

a way that the articular surface of the phalanx rests upon the back of the metacarpal bone immediately below its head. The signs of the accident are sufficiently evident. In the normal state of the hand, the metacarpo-phalangeal articulation of the thumb is convex backwards : in this dislocation it becomes convex towards the palmar aspect and angularly concave behind. The head of the metacarpal bone can be felt and seen projecting on the palmar aspect of the thumb. The proximal phalanx stands up as it were upon the back of this bone, but the articular surface of the phalanx cannot be felt, owing to its being in contact with the posterior part of the metacarpal bone just above its neck. The phalangeal articulation is always semiflexed. This dislocation of the proximal phalanx of the thumb has, owing to the difficulty of its reduction, attracted more attention from Surgeons than it would at first appear to deserve. So great has this difficulty been in some cases, as to render the dislocation irreducible, notwithstanding the employment of as much force as it was safe to use, and that most skilfully directed, or to compel the Surgeon to have recourse to operative interference in order to replace the head of the bone. The obstacle to the ready reduction of this small bone has been attributed to different causes. Thus, Hey supposed that it was owing to the constriction of the neck of the bone between the lateral ligaments of the joint. Dupuytren

entertained a very similar opinion, looking upon the malposition of these ligaments as the principal source of difficulty. The folding in of the anterior ligament of the joint, and the interposition of a sesamoid bone between the articulating surfaces, have also been regarded as giving rise to this peculiar difficulty in reduction. The more probable explanation, however, appears to be, that the narrow neck of the metacarpal bone becomes locked between, or constricted by, the two terminal attachments of the short flexor of the thumb, which must be carried back over its broader head, together with the displaced phalanx; the head of the metacarpal bone being grasped between these tendons and the torn capsule of the joint, like a stud between the sides of a button-hole. The observations of Vidal, Malgaigne, and Ballingall point to this as the cause of the great difficulty in reduction that is often met with.

Reduction.—Although, as has been said, great difficulty in reduction is often met with, it would be a great error to suppose that it always exists. On the contrary, very many of these dislocations are, under chloroform, most readily reduced by simple traction and manipulation. Should any difficulty

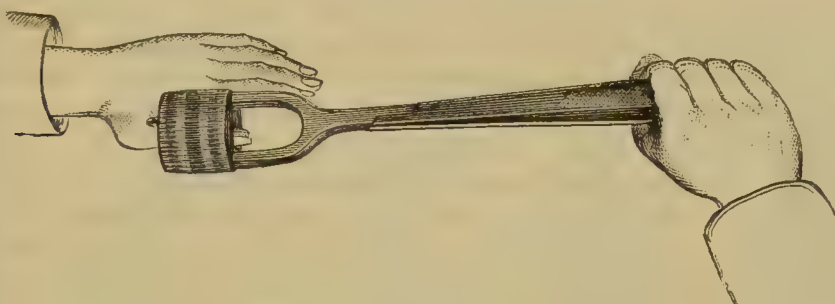


Fig. 285.—Reduction of Dislocation of Thumb.

be experienced, the following plan will usually answer. The hand and metacarpal bone being fixed by an assistant, the Surgeon bends back the thumb, so as to bring the phalanx to a right angle with the metacarpal bone on which it is displaced. He now employs traction in the axis of the displaced portion of the thumb, keeping the metacarpal bone well pressed down into the palm. Having thus unlocked the phalangeal articular surface from the back of that bone, he draws it well forwards, and, when it is opposite the head of the metacarpal bone, bends it down into the palm. In this way I have reduced a dislocation of the phalanx backwards between five and six weeks after its occurrence. Simple traction in the straight direction, however forcible, and even when aided by the pulleys, will do little, if any, good in the reduction of this dislocation, as the only effect is to draw the slit in the capsule and the two heads of the short flexor more tightly than ever round the neck of the bone. Very severe extension has been employed without any effect; and there is the tradition in the surgical profession in London of a thumb having been dragged off in the attempt to reduce this dislocation by pulleys. If the Surgeon fail in reducing the dislocated phalanx by manipulation under chloroform, as above described, or by traction, what is to be done? In these circumstances, the dislocation should not be left without a further effort to replace the bone; and this may usually be readily enough done by the subcutaneous section of the resisting structures. The Surgeon must bear in mind that the obstacle to reduction is purely mechanical; that muscular contraction has nothing to do

with it; and that it is quite as great when the patient is anæsthetized as when he is not. He must therefore enlarge the slit in the capsule, and divide the tense bands formed on each side by the tendinous attachments of the short flexor. This operation is best done by passing a tenotome through the skin in front of the joint, and cutting first on one side, then on the other. The chief resistance will be found on the ulnar side of the thumb, where the tendinous insertion of the adductor pollicis is probably divided at the same time as that of the short flexor of the thumb. After these structures have been cut through, the phalanx can be replaced, and the thumb should be put up securely between splints.

When reduction has been effected, care must be taken to prevent recurrence of the displacement. This is best done by keeping the thumb bent into the palm, and retaining it there by means of a gutta-percha cap moulded over it and bandaged down. If the dislocation be left unreduced, the thumb will to a great extent become useful, but necessarily shortened, deformed, and incapable of much flexion.

In *Compound Dislocation* of this joint, the bone may usually readily be replaced; should there be any difficulty in retaining the bone in position, the head of the metacarpal bone must be removed, the dislocation being then reducible with great readiness, and the wound treated in a simple manner.

Dislocations between the Phalanges rarely occur. These dislocations are partial or incomplete, and usually consist of a twist of the second upon the proximal phalanx. I do not think that simple dislocation of the ungual phalanx from the second is possible. Partial dislocation of the middle phalanx, which is a very common accident, is readily recognized by the deformity it entails (Fig. 286), and is easily reduced by pressure and traction in proper directions. A very convenient mode of applying traction is by means of the toy called an "Indian puzzle" (Fig. 285), which grasps the finger more tightly the more it is pulled upon. The finger will continue to be stiff and comparatively useless for some length of time; the joint being swollen and tender; the patient can generally bend it, but cannot extend it fully or bear any traction upon it. This condition is especially apt to be troublesome and chronic if the patient be gouty, or if his general health be otherwise deranged, and requires rest and local counter-irritation, with an anti-podagric treatment for its remedy. In *Compound Dislocation* of the phalanges, the bone should be replaced, the finger supported by a gutta-percha splint, and the wound dressed lightly. In some cases it is necessary to remove the projecting end of bone before this can conveniently be done: ankylosis then results, a sufficiently useful finger being left.

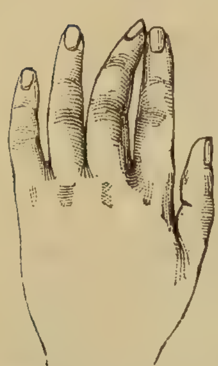


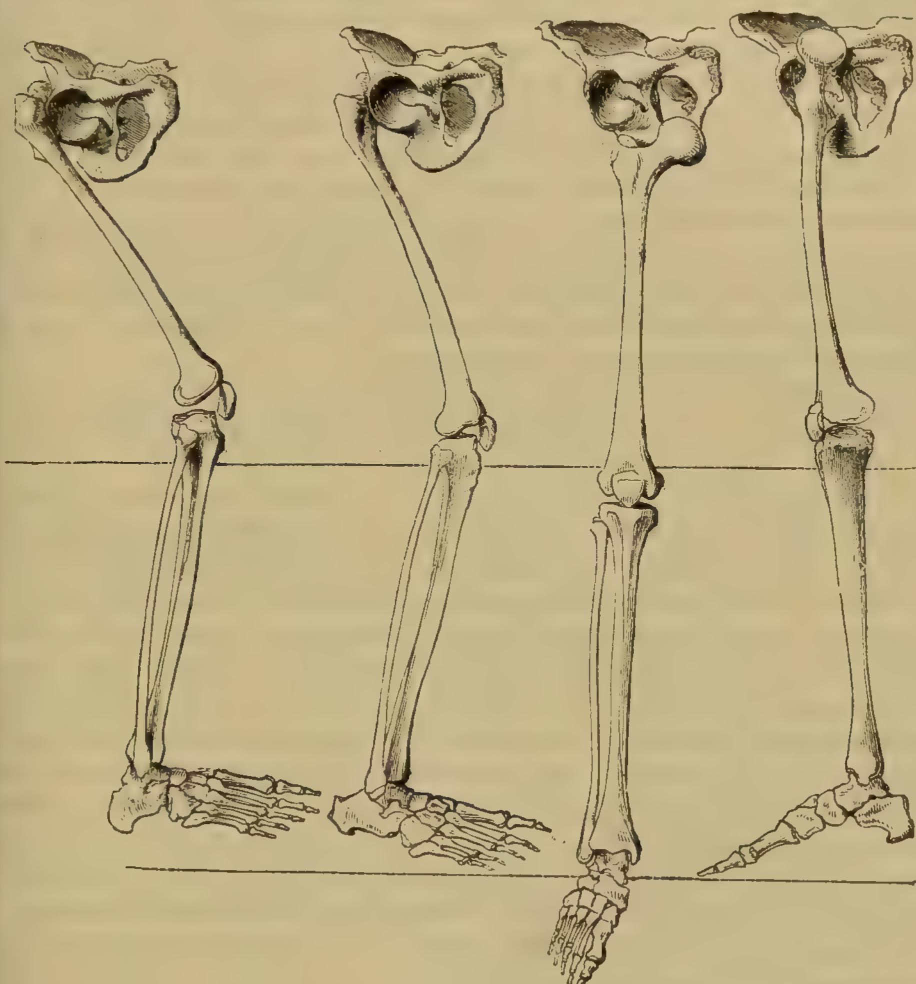
Fig. 286.—Partial Dislocation of the Middle Phalanx of the Middle Finger.

DISLOCATIONS OF THE LOWER LIMB.

Dislocations of the Pelvis.—It often happens that, in consequence of severe blows upon or compression of the pelvis, the **Symphysis of the Pubic Bones**, or more frequently the **Sacro-iliac Articulation**, is displaced. Here the nature of the injury is indicated by the deformity that results; and, the same treatment is required as in fracture of the pelvis, with which these accidents are commonly associated.

The **Coccyx** is sometimes violently bent, and almost dislocated *forwards* by falls; or it may be forcibly bent *backwards* during violent parturient efforts. These accidents may be remedied by manipulation through the rectum; but are apt to be followed by that painful neuralgic affection **Coccydynia**, described at p. 587.

Dislocations of the Femur.—Notwithstanding the great depth of the acetabulum, the complete manner in which the head of the thigh-bone is received into its cavity, the firmness of the capsular ligament, and the great



DISLOCATIONS OF THE HEAD OF THE THIGH BONE, ACCORDING TO ASTLEY COOPER'S CLASSIFICATION.

Fig. 287.—Upwards and somewhat Backwards, on Dorsum Ilii.

Fig. 288.—Backwards towards Sciatic Notch.

Fig. 289.—Downwards into Foramen Ovale.

Fig. 290.—Forwards and Upwards on the Pubic Bone.

strength of the muscles that surround and support the joint, dislocations of the hip are more frequently met with than those of many other joints that appear less perfectly supported. This is doubtless in a great measure owing to the action, on the head of the femur, of the great length of leverage of the thigh-bone itself when external violence is applied to the knee, and of the whole of the lower extremity when the violence is applied to the foot.

Dislocation of the hip-joint occurs chiefly in young or middle-aged adults In very old people, fracture of the neck of the femur will commonly be pro-

duced by the same violence that would have displaced the head of the bone at an earlier age. In children dislocation is rare, as the shaft generally gives way. Yet it does happen even at a very early age. Two cases have occurred in my practice at the Hospital. In one the bone was dislocated on the pubic bone, in a child a year and a half old ; in the other on the dorsum ilii in a boy of six.

The different forms of dislocation of the femur were described with great clearness and precision by Sir A. Cooper, according to whom the head is most commonly thrown **upwards and somewhat backwards**, so as to lodge on the slightly concave surface between the acetabulum and the crista ilii, resting on the gluteus minimus, and having the trochanter turned forwards (Fig. 287); or the head may be thrown **downwards** into the foramen ovale, lying upon the obturator externus muscle (Fig. 289) ; or **forwards and upwards** upon the horizontal branch of the pubic bone under the psoas and iliacus muscles, to the outer side of the femoral vessels (Fig. 290); lastly he described a variety in which the head of the bone was supposed to be thrown **backwards** into the great sciatic notch and to rest upon the pyriformis (Fig. 288). It has, however, since been shown that the peculiar features of this form are due, not to the head of the bone sinking into the notch, but to the relation of the neck of the femur to the obturator internus muscle.

The classification originally given by Sir Astley Cooper has been of late years slightly modified in accordance with the more accurate knowledge we now possess of the various forms of dislocation of the femur. It has been shown by experiments on the dead body that the most important structure in the mechanism of dislocation of the hip-joint is the **ilio-femoral ligament.** Gunn of Chicago, Busch, Von Pitha, and, more recently and fully, Bigelow, have insisted on an exact knowledge of this important ligament as constituting the basis of a correct understanding of the mechanism, not only of the various forms of dislocation of the hip, but also of the proper methods to be adopted for the reduction. Bigelow, to whom we are especially indebted for a most lucid exposition of the subject, has shown that the four commonly described dislocations of the hip could be demonstrated in the dead body after the whole of the muscular and ligamentous structures round the joint had been divided except the ilio-femoral ligament and the obturator internus muscle, which suffice to direct the limb to its appropriate position and to fix it there, the muscle being concerned only in the production of the dislocation described by Sir A. Cooper as "into the sciatic notch." The ilio-femoral ligament is of great strength. Bigelow has found its breaking strain in the dead body to range from 250 to 750 pounds. It is single above where it is attached to the anterior inferior spine of the ilium and divides below into two strong bands, one inserted into the upper and the other into the lower end of the anterior inter-trochanteric line, from which fact Bigelow gives it the name of the Y-ligament. The **obturator internus muscle** is also, as pointed out by Bigelow, a structure of great strength, owing to the intermixture of tendinous fibres with its muscular substance. In consequence of this arrangement it becomes practically an accessory ligament to the joint.

The observations of Bigelow have shown that wherever one or both of the branches of the ilio-femoral ligament remain untorn the head of the bone falls into certain definite positions giving rise to characteristic signs ; when the ligament is completely ruptured the position assumed by the bone is uncertain,

being due chiefly to accidental circumstances. He, therefore, divides dislocation into **Regular**, in which one or both branches of the ilio-femoral ligament remain untorn, and **Irregular**, in which the whole ligament is ruptured.

For convenience of description, and with a view to practical utility, the regular dislocations may be divided into three chief groups, to which must be added certain exceptional forms which are so rare as to require only mention.

1. **Dorsal Dislocations,** or **Dislocations Backwards and Upwards.**—Of these there are two varieties: *a,* when the head of the bone passes above the obturator internus (dislocation on to the dorsum ilii); *b,* when the head passes below that muscle (dislocation into the sciatic notch of Sir Astley Cooper) (Figs. 287, 288).

2. **Thyroid Dislocations,** or **Dislocations Downwards.**—These dislocations present four varieties, of which one only is common—obliquely inwards and downwards on the thyroid foramen (Fig. 289). In addition to this, there are three exceptional forms: *a,* inwards and downwards as far as the perinæum; *b,* vertically downwards below the acetabulum; *c,* outwards and downwards as far as the tuberosity of the ischium.

3. **Dislocations Upwards,** or **Pubic Dislocations.**—Of this form there are two varieties: *a,* when the head of the femur is displaced on to the pubic bone (Fig. 290); *b,* when it lies beneath the anterior inferior spine of the pubes, or the *sub-spinous dislocation.*

The exceptional forms of dislocation are the following:—

4. The **Anterior Oblique,** in which the head of the bone lies behind the anterior inferior iliac spine.

5. The **Supra-spinous,** in which the head of the bone lies above the anterior inferior iliac spine, between it and the superior spine.

6. The **Everted Dorsal Dislocation,** in which the head of the bone lies on the anterior part of the dorsum, behind the anterior inferior iliac spine. In the two last forms the outer branch of the ilio-femoral ligament is ruptured.

With regard to the *Relative Frequency* of the various forms of dislocation, Sir Astley Cooper says, that of 20 cases of dislocation of the hip, 12 will, on the average, be on the dorsum ilii (above the tendon of the obturator internus of Bigelow), 5 on the sciatic notch (below the tendon of the obturator internus), 2 on the thyroid foramen, and 1 on the pubic bone. Hamilton states that, excluding anomalous cases, of 104 dislocations which he has collected, 55 were on the dorsum ilii, 28 into the sciatic notch (below the tendon of the obturator internus), 13 into the thyroid foramen, and 8 upon the pubic bone.

In the **Reduction** of dislocations of the hip-joint, two methods may be employed, *extension* or *manipulation.* In extension, forcible traction is made by pulleys or otherwise in the direction of the axis of the limb, overcoming by main force any obstacle arising from muscular contraction or the mechanical resistance of ligaments. In manipulation force is avoided, the Surgeon's object being to relax the ligaments which offer a mechanical obstruction to reduction, and to disentangle the head of the bone from its abnormal position, and by impressing on it various rotatory movements, each adapted to the particular case, to bring it back into the acetabulum. Manipulation is mentioned by Hippocrates. The earliest modern description is by Thomas Anderson, Surgeon, of Leith, in the third volume of "The Medical and Philosophical Commentaries" for 1775. He describes two cases, one of dislocation on the foramen

ovale in a man—the other a dislocation on the dorsum ilii in a boy. In the first case the pulleys had been used ineffectually several times, when the "lacque" slipping, their use was discontinued. Mr. Anderson says: "I was convinced that attempting the reduction in the common method, with the thigh extended, was improper, as the muscles were put upon the stretch, the action of which is perhaps sufficient to overcome any extension we can employ. But by bringing the thigh to near a right angle with the trunk, by which the muscles would be greatly relaxed, I imagined the reduction might more readily take place, and with much less extension. *I raised the thigh to about a right angle with the trunk*, and, with my right hand at the ham, laid hold of the thigh, and made what extension I could. At the same time that I did this, with my left hand at the head and inside of the thigh, I pressed it towards the acetabulum, while my right gave the femur *a little circular turn*, so as to bring the rotula inwards to its natural situation, and at the second attempt it went in with a snap."

In the second case, the reduction was not attempted till the eighteenth day after the accident. The patient was laid across the bed, and *the thigh raised so as to form an acute angle* with the trunk. In this situation, the knee of the dislocated limb lay considerably over the sound thigh. "Considerable extension was then made; with my left hand I laid hold of the middle of the leg which I brought inwards. By this *the femur made a circular turn*, which directed its head towards the acetabulum, into which it went with a sensible noise" (pp. 426—428).

The method was, however, first distinctly advocated by Nathan Smith, in 1831, and extended by Reid, of Rochester (U.S.A.), in 1851; but it was not until the publication of Bigelow's work that the scientific principles of manipulation were fully laid down. At the present time no Surgeon would resort to extension by means of pulleys in a *recent* dislocation of the hip without having first attempted reduction by manipulation. In those of *old standing*, extension by means of the pulley is still required, as by manipulation sufficient force cannot be exerted to overcome those secondary causes of resistance that become developed in such cases.

After Treatment.—The fact of the reduction being accomplished is ascertained by comparing the bony points of the limb with those of the opposite side, and seeing if they correspond. A long splint and spica bandage should now be applied to fix the thigh, and the patient be kept in bed for a fortnight, so that reunion of the ruptured tissues may take place.

I shall describe both methods of reduction in connection with each of the principal forms of dislocation of the hip.

1. **Dorsal Dislocations,** or **Dislocation Upwards and Backwards.**—*Causes.*—The dislocations upwards and backwards which are most commonly met with in the hip, are occasioned by violence acting upon the limb while flexed and slightly adducted: as when a person is struck on the back with a heavy weight whilst kneeling, or is thrown forwards, or falls whilst carrying a heavy load upon his shoulders, when the upper and posterior part of the joint receives the whole strain. Thus, in a case under my care in University College Hospital, it was caused by a heavy weight falling from a crane upon a man's back as he was kneeling on one knee and reaching down to put a ticket on the side of a railway-truck. In another case it was caused by the patient's falling between the carriage and platform in a railway-station in such a way

that he lay on his side on the footboard with his knee against the platform and his back against the carriage. As the carriage slowly moved, his leg became flexed, and the space being insufficient, the head of the bone was pushed out of the socket. Bigelow states that if the femur is flexed at right angles, and thrust directly backwards with sufficient force to dislocate it, the head will tend to pass between the obturator internus and the pyriformis. At an angle of forty-five degrees, it may be thrust upwards and backwards above the pyriformis. Both these displacements would give rise to the symptoms of dislocation upon the dorsum ilii. In extreme flexion, or in cases complicated by forcible inward rotation, the head tends to pass out beneath the tendon of the obturator internus, and we then have the form of dorsal dislocation formerly described as dislocation into the sciatic notch.

Pathological Anatomy.—The capsule is ruptured behind, but the ilio-femoral ligament is intact in all dorsal dislocations. The ligamentum teres is mostly torn, but not necessarily in all. Dupuytren and Sédillot both mention cases of dislocation on the dorsum ilii in which this ligament escaped without rupture. In dislocation on the dorsum ilii, the head will be found lying in a variable position on the ilium, above and behind the acetabulum. The trochanter is directed forwards, being held in that position chiefly by the unruptured external band of the ilio-femoral ligament, which is very tense. The muscles are torn to a varying degree in different cases. Sir Astley Cooper found the gemelli, obturators, and quadratus, completely torn, and the pectineus slightly torn in one case. Syme found the gluteus maximus extensively torn, with the head of the bone imbedded in it; the gluteus minimus, the pyriformis, and the gemellus superior lacerated; and the head of the femur lying upon the gemelli and the great sciatic nerve. MacCarthy has described the appearances in another case. He found the deeper fibres of the gluteus maximus had been torn by the head of the bone, which was lying with its anterior part on the brim of the acetabulum, with the lowermost fibres of the gluteus minimus interposed, and the dimple for the ligamentum teres directed backwards and inwards. The posterior fibres of the gluteus medius were also torn, and the pyriformis, obturator internus, and gemelli muscles had been completely torn from their pelvic attachments. The quadratus femoris was uninjured. The capsule had given way posteriorly; in front and above it was intact. Although some fibres of the ligamentum teres had been ruptured, the ligament still resisted all attempts to break it. The ilio-femoral and pubo-femoral bands were uninjured, notwithstanding that the acetabulum had separated into its three component parts, the fracture traversing also the ilio-pectineal eminence. The lowermost fibres of the external oblique muscle of the abdomen, and some fibres of the sartorius, psoas magnus, and iliacus internus muscles were also ruptured. In all these cases it is evident that the bone had passed out above the obturator; in the last this muscle was torn.

In dislocations below the tendon of the obturator internus the position assumed by the bone is best explained by the accompanying figures taken from Bigelow's work on the Hip. Fig. 291 shows the normal position of the muscle behind the head and neck of the bone. It is evident that in a state of extreme flexion, or of moderate flexion with forcible internal rotation, the head might be made to pass out beneath the muscle. Immediately after the accident the limb is almost invariably extended either in lifting the patient or in placing him on his back. The ilio-femoral ligament being untorn, and

consequently the neck of the femur being more or less firmly fixed, the head moves upwards as the limb is extended till it comes to lie above the muscle in the position shown in Fig. 292, the obturator internus now lying in front of the neck of the bone and passing over it, thus limiting the displacement upwards. The injury to surrounding muscles is very various. Billard d'Angers found the gluteus maximus and medius lacerated and the gemelli torn, probably from the strain they had been subjected to from the position of the obturator. MacCarthy found the gluteus maximus not torn, but the bursa between it and the vastus externus was ruptured and filled with blood. The sheath of the great sciatic nerve was also distended with blood, and the

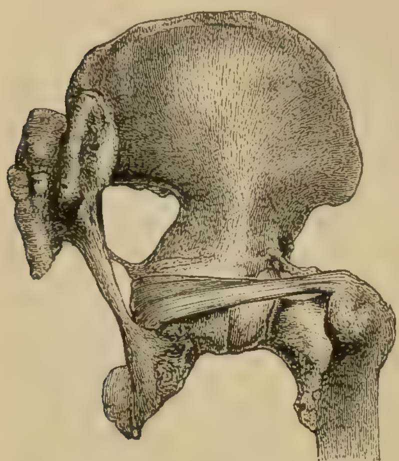


Fig. 291.—Pelvis and Head of the Femur with obturator internus in natural position. (Bigelow.)

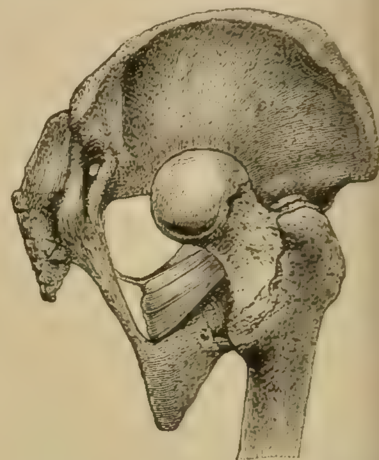


Fig. 292.—Pelvis and Head of Femur showing dislocation below the tendon of the obturator, with secondary displacement of the head upwards, and abnormal position of the obturator internus.

nerve-fibres separated from one another. The posterior fibres of the gluteus minimus were torn and the areolar tissue beneath the muscle filled with blood. The quadratus femoris muscle was torn completely in two, and the uppermost fibres of the adductor magnus, and some fibres of the gemelli and obturator internus muscles, were lacerated. The capsule was perfect in front and above, but torn at the most posterior part. The ligamentum teres had been torn off close to the femoral attachment.

The accompanying drawing (Fig. 293) is from a case which was admitted into University College Hospital. The patient died from other injuries a few hours after admission. The dislocation was reduced without the slightest difficulty by manipulation and showed no tendency to slip out again, though the man was very restless before death. The dislocation was easily reproduced after the limb had been dissected and rigor mortis had passed off. A considerable extravasation of blood was found beneath the gluteus maximus. The only muscle torn was the gemellus inferior, the upper border of the quadratus was slightly bruised, and the lower border of the gluteus minimus was also marked by a little extravasated blood, apparently from the pressure of the head of the bone in its abnormal position, and there was extravasated blood in the sheath of the great sciatic nerve. A small fragment had been chipped from the margin of the acetabulum, but was firmly fixed by the capsule.

Symptoms.—If the head of the bone have been displaced *above the*

obturator and upon the dorsum of the ilium, the hip will be found to be a good deal distorted, the gluteal region being somewhat prominent, and the upper part of the thigh enlarged, in consequence of the approximation of the muscular attachments, so as to give an appearance of widening to the hip. The head of the bone can be felt in its new situation, more especially on rotating the limb; the trochanter is less prominent than natural, usually lying close against the brim of the acetabulum, and being turned forwards; there is marked shortening, varying from one to two inches in some cases, perhaps even as much as three inches. The amount of shortening will necessarily depend upon the distance to which the head of the bone is thrown *upwards* on the dorsum. The position of the limb is remarkable, being dis-

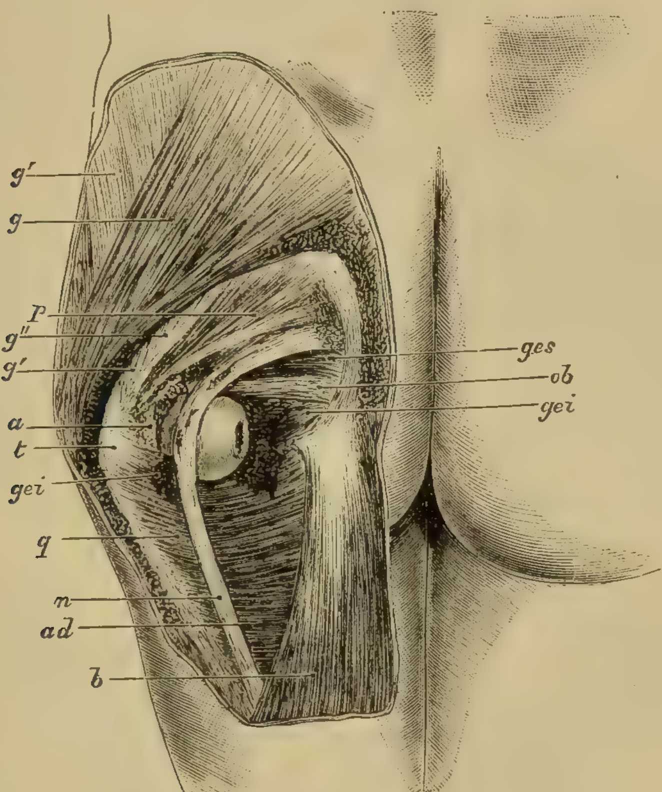


Fig. 293.—Dorsal dislocation below the tendon. *g*, *g'*, *g''*, Gluteus max., medius, and minimus; *p*, pyriformis; *a*, attachment of capsule; *t*, trochanter; *gei*, gemellus inferior; *q*, quadratus; *n*, great sciatic nerve; *ad*, adductor magnus; *b*, biceps; *ob*, obturator internus; *ges*, gemellus superior.

tinctly rotated inwards, with the thigh slightly bent upon the abdomen, and the leg upon the thigh, so that the knee is semi-flexed, and raised from the surface on which the patient is lying. The foot is inverted, so that the ball of the great toe rests on the instep or against the ankle of the sound limb; and the heel is somewhat raised. The axis of the dislocated thigh is directed across the lower third of the sound thigh. The movements of the joint are greatly impaired: abduction and eversion are not practicable; but inversion, adduction, and some flexion upon the abdomen, can be practised. When the patient is lying flat, with the knee slightly raised and advanced, the lumbar spine is on its proper level; but if an attempt be made to straighten the knee, so that the limb lies flat, the lumbar spine will arch forwards.

The slight flexion, the rotation inwards, and the adduction are all due to the position in which the neck of the bone is held by the unyielding ilio-femoral ligament; flexion and adduction are easy because by approximating the intertrochanteric line to the anterio-inferior pubic spine they relax the ligament.

When the head of the bone has escaped *below the tendon of the obturator* we have the dislocation formerly described as into the sciatic notch, and to which the name of "sciatic" is still usually applied. If seen immediately after the accident there may be extreme flexion and adduction, the dislocated limb crossing the sound thigh near the groin, but usually before the Surgeon sees the case the limb has been brought down so that the head has gone up behind the obturator. The symptoms then resemble those of the dislocation on to the dorsum ilii, differing chiefly in degree. The inversion of the knee and foot is more marked, and consequently the trochanter is less prominent than in the dislocation on the ilium; the shortening is very much less, as it is limited by the obturator internus in its abnormal position; it seldom exceeds an inch and is usually not so much. The position of the limb will depend upon the degree to which the thigh has been extended since the accident. In the erect position the weight of the limb brings it down so that the axis of the thigh may be directed across the sound knee, and the toes of the injured side may rest on those of the opposite foot. Thus it may closely resemble a dislocation on the dorsum ilii, the most important difference being the small amount of shortening when the head has escaped below the tendon. By violent manipulation or extension the obturator internus may be torn, and the lower dislocation may thus be converted into one on the dorsum ilii.

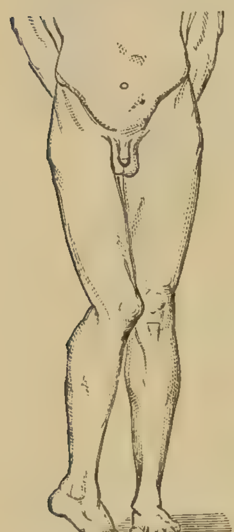


Fig. 294. — Dislocation below the Tendon. Much nversion. (Bigelow.

The *Diagnosis* of this form of dislocation is easy in proportion as the head of the bone lies high on the dorsum ilii. The lower it is placed the more difficult does the detection of the displacement become, and the greater the risk of its being overlooked altogether, or mistaken for a sprain. In ordinary cases of fracture of the neck of the thigh-bone, the eversion of the limb at once points out that the head of the bone is not dislocated on the ilium. The only severe injury of the hip with which the dislocation upwards and backwards can be confounded, is the rare case of *fracture of the neck of the thigh-bone, with inversion of the limb.* In this accident, the increased mobility, and the existence of crepitus, will enable the Surgeon to effect the diagnosis. Should, however, the case be one of *impacted extracapsular fracture, with inversion,* then the difficulty of diagnosis is undoubtedly great. A correct conclusion may, however, be arrived at by observing that in the fracture the flattened trochanter is approximated to, and is in nearly a perpendicular line with the anterior superior spine of the ilium; whilst in the dislocation the trochanter is diagonally behind that process of bone, and the head of the thigh-bone can be felt in its new situation by deep manipulation of the gluteal region.

Reduction of Dorsal Dislocations by Manipulation.—The patient must be laid upon his back on a mattress on the floor and fully anæsthetized, the Surgeon standing on the injured side. There are two chief ways in

which reduction may be effected, by *traction* and by *rotation*. Traction is thus performed :—

Flex the thigh upon the abdomen, bending the limb at the knee to a right

Fig. 295.—Reduction of a Dorsal Dislocation of the Hip by Traction.

angle (Fig. 295). The flexion relaxes the ilio-femoral ligament, and the relaxation may be further increased by slight adduction ; then rotate very slightly inwards ;

Fig. 296.—Reduction of a Dislocation by Rotation. The Thigh is flexed, slightly adducted, and rotated inwards, as in the first stage of reduction of a dorsal dislocation.

that is to say, move the foot away from the middle line while the knee is held steady. This disengages the head from behind the socket ; slight traction in

the line of the femur will then usually bring the bone into position ; if more force is required the Surgeon may place his foot, covered only with a stocking, on the anterior superior spinous process, to steady the pelvis while he raises the bent knee. In the great majority of cases reduction will be easily effected by this plan.

Rotation is thus performed. The Surgeon, standing on the injured side, grasps the ankle with one hand and the knee in the other as in Fig. 296. He then steadily flexes the thigh upon the abdomen, so that the head of the bone is lifted out from behind the acetabulum and the ilio-femoral ligament relaxed. At the same time that the thigh is flexed it is better to keep it slightly adducted. The limb must now be slowly abducted, and finally rotated outwards by bringing the foot of the injured side over the sound leg. By this manœuvre the head is made to revolve around the great trochanter, which is fixed by the outer branch of the Y-ligament, and to rise into its articular cavity (Fig. 297). Finally the limb is brought down parallel to the other. Bigelow has summarised the movements necessary to effect reduction this way in the following words, "*Lift up, bend out, roll out.*"

Fig. 297.—Dorsal Dislocation. Reduction by Rotation. The limb has been flexed and abducted, and it remains only to rotate it outwards, and so to render the outer Branch of the Y-ligament tense. (Bigelow.)

Reduction by Extension, according to Sir Astley Cooper's method, is effected in the following manner. The patient, having been put under the influence of chloroform, is laid on his back upon a strong table. One staple should then be fixed in the floor near the head of the bed at the side corresponding to that of the dislocated limb, while another staple is placed in the wall at the foot, above the level of the body, in a direct line with the axis of the limb, and about twelve feet from the other. The counter-extending force must then be made by a jack-towel or a padded leather-belt passed between the injured thigh and the perinæum, and fixed to the staple in the floor. The pulleys must now be attached to proper straps, or to a towel fixed with a clove-hitch knot immediately above the knee, at one end ; the other extremity being attached to the staple in the wall, which should be so situated as to be continuous with the axis of the lower part of the limb. The knee being then slightly bent and rotated inwards, traction is applied slowly and steadily until the head of the bone has approached the acetabulum, when the Surgeon rotates the limb outwards so that the head may slip into its socket (Fig. 298).

This method is seldom, if ever, required in recent dislocations. Should it be necessary, as in an old dislocation, it would be better to flex the thigh more than is shown in the figure after the bone had been brought down as far as possible by extension in the axis of the limb.

Reduction of the Dislocation below the Tendon of the Obturator is effected by the same processes of manipulation as in the other form of the dorsal dislocation. The first method, that of traction, is usually at once

successful. Sir A. Cooper found great difficulty in the reduction of this dislocation, and he, Lisfranc and other Surgeons, have failed to reduce it by extension. They believed that the difficulty arose from the head of the bone sinking into the great sciatic notch. The fallacy of this view and the part played by the obturator internus in resisting reduction by extension in the

Fig. 298.—Reduction of Ilio-sciatic Dislocation by Extension.

axis of the limb has been already pointed out. Should *extension* be necessary, it must be made with the thigh flexed at a right angle to the trunk.

In either of these dislocations, if difficulty arise in raising the bone over the edge of the acetabulum, recourse may be had to the plan recommended by Sir Astley Cooper, of lifting the head of the bone over the edge of the acetabulum by means of a round towel placed under the upper part of the thigh and over the shoulders of an assistant, who, first stooping and at the same time resting his foot on the patient's pelvis, should then raise his shoulders and draw the bone towards its socket.

Fig. 299.—Dislocation Downwards and Outwards towards the Tuberosity below Tendon. (Bigelow.)

Dislocation downwards and outwards towards the tuberosity of the ischium is described by Bigelow as closely allied to the dorsal dislocation below the tendon. It arises from *causes* similar to those giving rise to a dorsal dislocation, applied when the thigh is fully flexed on the abdomen. The head of the bone bursts out through the capsule and passes below the tendon of the obturator internus, rupturing the gemellus inferior and quadratus, and comes to lie close to the tuberosity of the ischium. It can be felt in this situation ; there is extreme flexion and adduction and rotation inwards (Fig. 299). On extending the limb, the neck of the bone remaining fixed by the ilio-femoral ligament, the head passes upwards behind the tendon of the obturator internus, and the dislocation is thus converted into an ordinary "dorsal below the tendon."

Dislocations of the head of the femur directly backwards with fracture of the brim of the acetabulum may occur when a heavy weight falls on to the back of a person who is kneeling. In this case the pelvis is driven down violently on to the femur, which is forced against the ground at its lower end. The impact of the blow drives the posterior part of the brim of the acetabulum against the head of the femur, and this is thrust through the capsule at its

posterior part. It is, perhaps, rather the pelvis that is thrust forwards than the femur backwards—but the result is the displacement of the head of the bone, and its being lodged directly backwards behind the cotyloid cavity.

2. **Dislocation Downwards**, or **Thyroid Dislocations.**—*Causes.*—This dislocation appears to be occasioned by the limb being suddenly and violently abducted, as by falls with the legs widely separated ; in consequence of which the head of the bone is tilted against the inner side of the capsule, and, rupturing this, is thrown on the thyroid foramen.

Pathological Anatomy.—The head of the bone escapes by a laceration of the inner side of the capsule where it is thin and membranous. The ilio-

Fig. 300.—Thyroid Dislocation. (Bigelow.)

Fig. 301.—Reduction by Manipulation in Thyroid Dislocation. Rotation and Circumduction Inwards of Head of Femur. (Bigelow.)

femoral ligament is untorn, and holds the root of the neck up while the head descends, and passes somewhat inwards ; consequently the femur is flexed and abducted. The round ligament is torn. The pectineus and adductor brevis muscles have been found to be torn in this injury.

Symptoms.—The hip is flattened, and the prominence of the trochanter completely absent, or indeed replaced by a depression. The limb is lengthened by about two inches, advanced before the other, and considerably abducted (Fig. 300). The knee is bent and incapable of extension ; the foot usually points forwards, but is sometimes slightly everted and widely separated from its fellow. When the patient stands, the body is bent forwards, partly to accommodate the pelvis to the flexed position of the limb dependent on the ilio-femoral ligament, and partly on account of the tension of the psoas and iliacus muscles ; and in a thin person the bone may be felt in its new situation. When he lies on his back the knee is much raised, the thigh being flexed, according to Bigelow, to an angle of 35°.

Reduction by Manipulation must be done by rotation or traction as follows. In *rotation* the limb, having been flexed on the abdomen so as to bring it into a perpendicular position, must be slightly abducted so as to disengage the head of the bone. The thigh is then to be strongly rotated inwards, and adducted, the knee being carried towards the floor (Fig. 301).

Reduction by *traction* may be done thus: the Surgeon flexes the limb and abducts it, and then placing his foot upon the side of the pelvis, pulls or jerks the thigh in the direction in which the head is required to go to reach the socket. If more force is required a towel may be put round the lower part of the thigh.

Reduction by Extension is to be done in the following manner. The patient is laid on his back; the counter-extending girth, or towel, is then

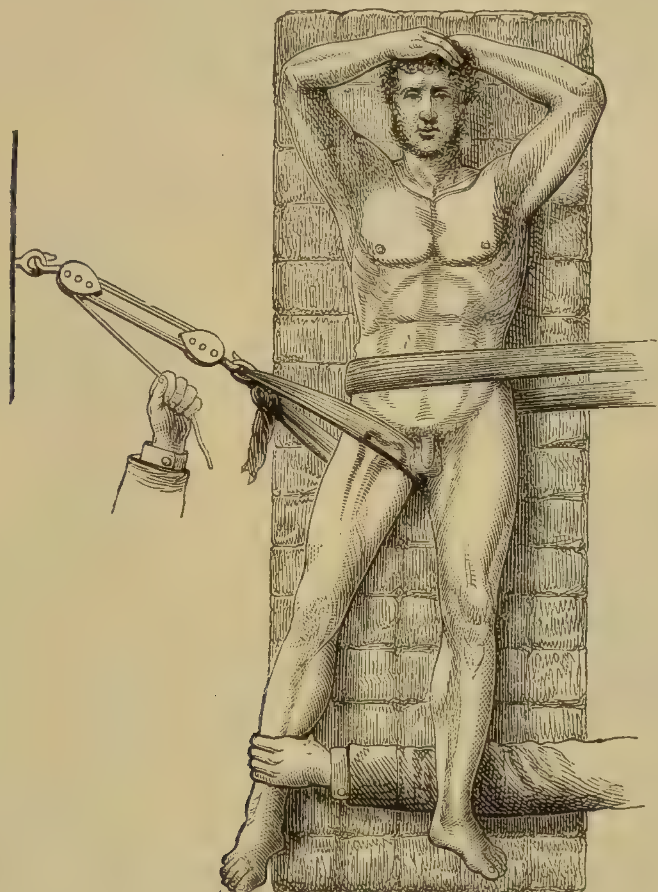


Fig. 302.—Reduction by Dislocation into Thyroid Foramen by Extension.

placed round the pelvis and fixed firmly to a staple next to the sound side of the patient. A padded girth is then to be placed between the perinæum and the upper part of the dislocated thigh. From this, extension is made by means of the tourniquet or the pulleys, which are fixed to a staple at a little distance from the injured side of the patient. Extension having then been made to such a degree as to elevate the head of the bone from the depression in which it lies, the Surgeon passes his hand behind the sound leg, and, seizing the ankle of the injured limb, presses it backwards and draws it towards the mesial line, taking care to keep the knee straight, and thus throwing the head of the bone into the acetabulum by the action of a long lever (Fig. 302),

The following are more rare forms of dislocation downwards.

The head of the thigh-bone may be thrown **directly downwards,** so as to rest *on the lower margin of the acetabulum,* between the sciatic notch and the thyroid foramen. Two cases of this injury have been recorded by Gurney

of Camborne, and one by Luke. In it there is less eversion of the limb than in the thyroid dislocation (Fig. 303). Bigelow has pointed out that the head of the bone, when thrown below the lower margin of the acetabulum, may be further displaced; either backwards on the dorsum ilii, or forwards to the thyroid foramen. In extreme flexion, however, the head may pass down as far as the *tuberosity or the ascending ramus of the ischium;* in the former case the limb is everted, and in the latter inverted, and in all cases flexed. The head of the bone may pass also **into the perinæum,** so as to be felt in its abnormal situation behind the scrotum. It has been known to compress the urethra, and thus give rise to retention of urine. The thigh is extremely abducted and stands out at a right angle with the body; and the toes may be

Fig. 303.—Dislocation directly downwards. (Bigelow.)

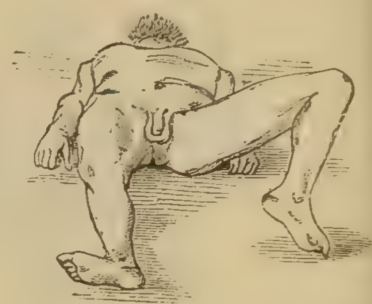


Fig. 304.—Dislocation downwards and inwards towards Perinæum.

either inverted or everted—which is ascribed by Bigelow to the want of firm bearing for the trochanter in the perinæum (Fig. 304).

In the **Reduction by Manipulation** of these two rare forms of dislocation downwards, the thigh is to be bent and its head guided towards the socket. During this, the dislocation is sometimes converted into one of the thyroid or dorsal variety. In the dislocations downwards, vertical traction and slight inward rotation may be used; in the dislocations downwards and outwards, traction upwards and inwards, with abduction and rotation outwards; in the displacement downwards and inwards, traction upwards and outwards.

Probably allied to these forms of dislocation is that in which the head of the bone has been found thrown **downwards and backwards towards the lesser sciatic notch.** In these cases there is considerable shortening, but the position of the limb appears to vary. In an instance that occurred to Keate, the limb was abducted and the toes turned outwards. In a case reported by Wormald, the limb was turned inwards. Although the limb is described as shortened in these cases, Warren has related a case in which it was elongated.

Dislocation Upwards, or Pubic Dislocation.—The *Cause* of this dislocation is either direct violence applied to the back of the thigh whilst the limb is abducted; or it arises from the patient making a false step in walking, and suddenly throwing his body backwards in order to avoid a fall, twisting and displacing the limb.

Pathological Anatomy.—The capsule is lacerated at its inner aspect, the ilio-femoral ligament remaining untorn and causing rotation of the limb outwards:

the obturator internus is tense and holds the limb backwards, being the chief agent in preventing flexion; the gemelli are stretched or torn, and the quadratus femoris has also been found to be ruptured. In one case related by Sir A. Cooper, Poupart's ligament was torn up, and in another the pectineus and adductors were torn; but whether this was done by the dislocation or by the direct injury that occasioned it, is uncertain.

Symptoms.—The dislocation upwards **on the Pubic Bone** presents very unequivocal signs. The hip is flattened; the head of the bone can be distinctly felt lying in its new situation above Poupart's ligament, to the outer side of the femoral vessels, where it may be made to roll by rotating the limb. The thigh and knee are slightly flexed, rotated outwards, and abducted; the limb, which is separated from its fellow, is shortened to the extent of an inch (Figs. 305, 306).

The **Reduction by Manipulation** can be effected by traction and rotation, or by rotation alone. The former is effected by drawing the limb downwards.

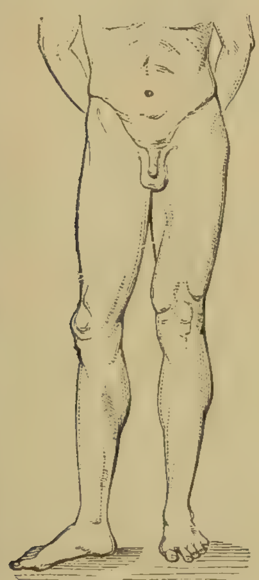


Fig. 305.—Pubic Dislocation.. (Bigelow.)

Fig. 306.—Pubic Dislocation. Head of Bone in Groin suspended by Y-ligament. (Bigelow.)

and at the same time raising it up so as to flex it gradually on the abdomen as the head of the femur becomes disentangled from its position. It may then be rotated inwards, and the head of the bone thus directed towards the acetabulum.

By *rotation.*—Bigelow recommends it to be thus accomplished: semi-flex the thigh so as to relax the ilio-femoral ligament, and to bring the head down from the pubes; then abduct and rotate inwards to disengage it completely; lastly, while rotating inwards and drawing on the thigh, carry the knee inwards and downwards to its place by the side of its fellow.

With regard to the **Reduction by Extension,** Sir Astley Cooper advises that the patient should lie upon his back with his legs widely separated; and that, counter-extension being then made by a girth carried between the perinæum and the injured thigh, and fixed to a staple in front of and above the body, the pulleys should be fixed upon the lower part of the thigh, and the

extension made downwards and backwards. After this has been continued for a sufficient time, an assistant lifts the head of the bone by means of a towel over the brim of the acetabulum (Fig. 307).

The head of the thigh-bone may also be thrown **under the anterior**

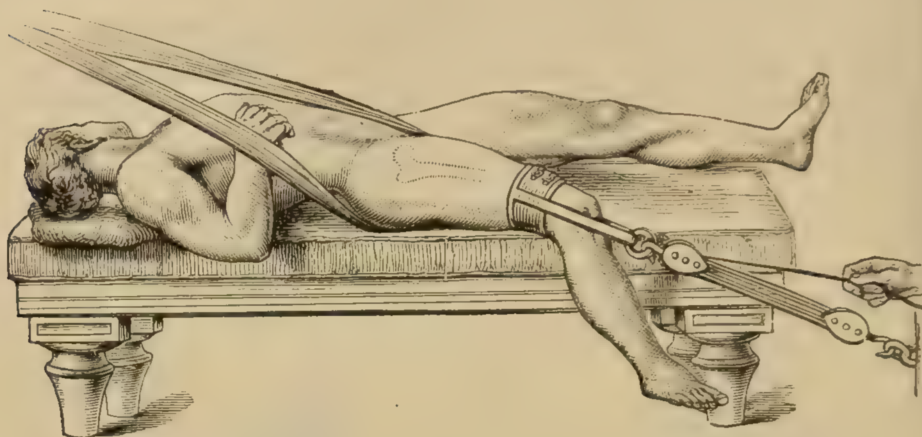


Fig. 307.—Reduction of Pubic Dislocation by Extension.

inferior spinous process, constituting the **Subspinous Dislocation** of Bigelow. There is shortening of the limb, which is everted, but less abducted or advanced than in the dislocation on the pubes. The head of the bone can be felt in its new situation. One peculiarity of this dislocation is that in some of the recorded cases the patient has been able to walk immediately after the accident. Bigelow explains this by the position of the Y-ligament over the upper part of the neck of the femur (Fig. 308). Reduction of the dislocation is accomplished in the same way as in the pubic form.

Fig. 308.—Subspinous Dislocation. The Y-ligament is stretched across the Neck of the Bone, which lies beneath it. (Bigelow.)

In the dislocations above described the Y-ligament remains entire. Bigelow describes also **Supraspinous dislocation** with or without rupture of the outer branch of the ligament. In this dislocation the head of the bone leaves the socket on the outer side of the ilio-femoral ligament. If this be not ruptured, the dislocation is called by him *anterior oblique:* in it, the thigh lies across the upper part of the corresponding limb, and is firmly locked in that position, with much shortening and some eversion. Reduction may be effected by extension of the limb and increased circumduction across the symphysis, with a little eversion if necessary to dislodge the head of the bone. By inward rotation, the head of the bone is thrown on the dorsum.

In the true *supraspinous dislocation*, the outer branch of the Y-ligament is ruptured : the limb is shortened and everted. In a case related by Cummins, the limb was shortened three inches. Reduction may be effected by circum-

duction inwards and eversion, by which the dislocation is rendered dorsal, and may be then reduced as already directed.

Everted Dorsal Dislocation may occur when, in dislocation on the dorsum, the outer branch of the Y-ligament is broken: the integrity of this portion being necessary for the inversion of the limb.

Irregular Dislocations of the head of the thigh-bone occur when the Y-ligament is wholly ruptured. The displacement may take place in any of the above-described directions: but the characters are inconstant.

Reduction of old Dislocations of the Hip-joint is attended not only with great difficulty, but with no small amount of danger. The probability of effecting reduction rapidly decreases with the length of time that the bone has been left unreduced, and more rapidly in some dislocations than in others. Thus it is easier to reduce an old dislocation on the dorsum ilii than one below the tendon of the obturator internus. Dislocation of the head of the thigh-bone on the dorsum of the ilium may usually be reduced without any great difficulty, up to the end of the first fortnight. After that time the difficulty increases considerably; and, although reduction has frequently been effected in these cases up to the sixth or eighth week, yet it has also not unfrequently failed, notwithstanding persevering and repeated attempts. After two months have elapsed, the reduction is not only a work of great uncertainty, but also of no slight danger from suppuration in the soft parts, or fracture of the femur; and it is then seldom practicable. But cases have been reported, and are referred to at p. 633, in which these dislocations have been reduced at a much later period, even as late as six or nine months.

If the bone be left permanently unreduced, it will in time acquire considerable mobility, more particularly in the lower dorsal dislocation, the patient walking readily with a shortened but otherwise useful limb.

The attempt to reduce old dislocations of the hip-joint is necessarily attended with more or less danger. In some cases the soft parts have been extensively lacerated; in others fatal inflammation of the joint has ensued; and, in eleven cases with which I am acquainted, the thigh-bone was fractured. This accident has happened to Surgeons of such eminence as Travers, Vincent, Malgaigne, Physick of Philadelphia, to Gwynne of Brighton, to Blackman of Cincinnati, to Harris and Randolph of the Pennsylvania Hospital, to the Surgeons of the Northern Hospital in Liverpool, and to a practitioner in London now living. In most of these cases the bone gave way at its neck or below the trochanters; the dislocation was of course left unreduced, but the patients recovered without difficulty, the fracture being treated in the usual way. The cause of the fracture appears usually to have been the employment of force in a transverse or rotatory manner, after extension had been kept up for some considerable time. There is no proof that undue violence was used in any of these cases. It is probable that in some the femur had become weakened by disuse of the limb.

The **Complication of Fracture of the Femur with Dislocation of the Hip-joint** occasions a very serious state of things, that may baffle the most skilful efforts on the part of the Surgeon. The line of practice to be adopted must depend in a great measure on the seat of fracture. If this be situated below the middle of the thigh, the limb should be put up tightly in temporary splints, and an attempt made under chloroform to reduce the dislocation in the ordinary way, by manipulation or by pulleys applied over the splints. If

the fracture be high up, near or at the neck, the patient should be put under chloroform, and an attempt then made by pressure on the dislocated head and by manipulation to replace it. It is possible that this might be effected, as in similar injuries of the humerus, with comparatively little trouble. Should reduction in this way not be practicable, we may adopt the plan successfully employed by Badley, who, in a lad of eighteen, with dislocation on the dorsum ilii, and fracture of the displaced bone, allowed union of the fracture to take place, and then, at the end of five weeks, effected reduction.

Simultaneous Dislocation of both Hips, perhaps in different directions, or of one hip with fracture of the opposite thigh-bone, has been met with in some rare instances.

Congenital Dislocation of the hip is by no means rare; it occurs most frequently in girls, and may affect either one hip or both. The dislocation is almost invariably on the dorsum ilii, though other varieties have been met with. When it is double, the deformity being symmetrical, is seldom recognized till the child begins to walk. The signs of the affection are in most cases clearly marked. The situation of the heads of the bones behind their natural position causes the pelvis when the patient is erect to be tilted forwards, carrying with it the last lumbar vertebra; to compensate for this there is a curve backwards in the upper lumbar and lower dorsal vertebræ. Thus the lumbar spine forms a very extreme curve, with its convexity forwards (lordosis); the trochanter is approached to the anterior superior spine of the ilium, and the head of the bone may be seen on the dorsum ilii; the thigh seems shortened and is more or less adducted, and the toes may be straight or directed inwards; the patient walks fairly well, but with a peculiar rolling motion. Little can be done in the way of treatment, though much has been recommended. If the patient walks well, nothing is needed; but in some cases a properly constructed support gives relief and increased steadiness. The best apparatus is a firm, well-padded, metal belt, to encircle the pelvis between the trochanter and the crest of the spine. On each side of this is fixed a carefully moulded cap of thick leather to fit the displaced head and trochanter; from the belt opposite the cap a steel rod may reach up to the arm-pit on each side, ending in a crutch to take a part of the weight of the body, and a properly fitted pair of stays attached to the rod will also tend to support the trunk. The object of the apparatus is to throw a certain part of the weight of the upper portion of the body directly on the displaced heads of the bones. The belt should be fitted to the child while it is lying down and some forcible extension is being made to the limbs so as to increase the space between the trochanter and the crest of the ilium as much as possible, and if accurately made will tend to maintain this in the erect position.

Dislocations of the Patella are not frequently met with. They may, however, occur in four directions, viz., *outwards*, *inwards*, *edgewise* or *vertically*, and *upwards*.

1. The dislocation **Outwards** is the most common variety of the accident: the bone being thrown upon the outer side of the external condyle of the femur, with its axis directed somewhat backwards and downwards, so that the inner margin is directed forwards. The knee is flattened in front, and is broader than usual; the patella can be felt in its new situation, and the muscles that form the quadriceps extensor are rendered tense, more especially the vastus internus; the leg is sometimes extended, but more frequently the

knee is slightly flexed. This accident usually happens from sudden muscular contraction, especially in persons who are knock-kneed. In some cases it has been occasioned by direct violence, driving the bone out of its position. Most frequently, the patella is only partially displaced outwards, with some rotation of the bone in the same direction.

Holthouse (*Lancet*, vol. ii., 1872) has recorded a case of *congenital* dislocation of the patella outwards. The abnormality was met with in a boy aged seven, who had been admitted into the Westminster Hospital for fracture of the left femur. Whilst putting up the fracture, it was observed that the right patella was so displaced that its inner articular facet rested on the outer condyle, and that when the knee was flexed the dislocation became complete. There was no inclination inwards of either knee. The mother alleged that the condition had existed from birth, and that at first both knees were affected. The boy could run and jump as well as other children, and was not more liable to fall than they.

2. The dislocation **Inwards** is very rare ; Malgaigne, who has investigated this subject, is of opinion that there is only one case of the kind on record.

In these lateral dislocations, *Reduction* may be effected by laying the patient on his back, bending the thigh on the abdomen, and raising the leg so as to relax the extensor muscles. The Surgeon then, by pressing down that edge of the patella which is furthest from the middle of the joint, raises the other edge, which, being tilted over the condyles, is immediately drawn into position by the action of the extensors.

3. A remarkable form of dislocation of the patella is that in which this bone becomes twisted upon its axis in such a way that it is placed **Vertically**, one of its edges being fixed between the condyles, and the other projecting under the skin, and pushing this forwards into a distinct tumour. According to Malgaigne, the outer edge is most commonly fixed in the intercondyloid notch ; Streubel, however, who has collected 120 cases of dislocation of the patella, states that one-sixth of these were vertical dislocations, and in about two-thirds of these the outer edge was forwards. In some cases, as those of Woolf and Mayo, the bone has been turned almost completely round, the posterior articular surface becoming partly anterior. The signs of this dislocation are evident, manual examination indicating the vertical displacement of the patella, with a deep depression on each side. The limb is completely extended, flexion being impossible.

This dislocation has most generally arisen from sharp blows or severe falls upon one edge of the patella, whilst the limb has been semiflexed, in consequence of which the bone appears to have been semi-rotated and fixed in its new position. Violent muscular contraction, however, conjoined with a twist of the leg, but without any blow, has been known to produce it in some cases.

The *Reduction* of this displacement has sometimes been very difficult ; in other cases it has been readily effected ; whilst in two or three instances it has been found to be quite impracticable ; Surgeons having ineffectually attempted, by means of elevators and the section of the tendons or of the ligamentum patellæ, to replace the bone, and the patient having eventually died from septic suppuration of the joint, with the displacement unrelieved. The cause of this difficulty of reduction is not very distinctly made out ; it is certainly much greater than can be explained by simple muscular contraction, and may not improbably be owing to the aponeurotic structures which cover the

bone becoming twisted or entangled under it, or, as Malgaigne supposes, to the superior angle of the bone being wedged in the *subcondyloid* space. If relaxation of the muscles of the thigh, and the employment of proper pressure upon the patella, do not succeed, reduction may perhaps be effected by the patient making a sudden and violent muscular effort at extension of the limb, or by attempting to walk. In other cases the bone has been readily replaced by bending the leg, and rotating it on the axis of the tibia, at the same time that the patella is pressed into position, as Vincent recommends. Upon the whole, forcible flexion of the knee under an anæsthetic followed by sudden extension, while the projecting edge of the bone is forced into its place, appears to have answered better than any other method, and will probably be seldom attended by difficulty. Should these plans not answer, I do not think it would be advisable to have recourse to subcutaneous section of the tendon of the quadriceps extensor and of the ligamentum patellæ. In one case in which both these structures were divided, the patella remained as firmly fixed as ever, and the patient eventually died of suppurative inflammation of the knee-joint; and in no case in which division has been practised does it appear to have facilitated reduction.

4. Dislocation of the patella **Upwards** can occur only in consequence of the rupture of its ligament. This accident, which is always accompanied by much inflammation of the joint, requires the same treatment as a fractured patella.

Dislocations of the Knee.—This joint, owing to the breadth of its articular surfaces, and the great strength of its ligaments, is seldom dislocated. When such an accident happens, it usually arises from falls from a great height, or by the patient jumping from a carriage in motion. The tibia may be displaced in four directions: *to either side, forwards, or backwards.* Besides these displacements, the joint is subject to a partial luxation, dependent upon displacement of one or both semilunar cartilages.

1. The **Lateral** dislocations of the tibia are the most common. They are always *incomplete*, and are usually accompanied by a certain degree of rotation of the limb outward. These displacements may either be **External** or **Internal**. In the first, the outer condyle of the femur rests upon the inner articular surface of the tibia. In the other, the inner condyle is placed upon the outer articular surface of the head of this bone. In either case, the knee is slightly flexed; there is a marked sulcus in the situation of the ligamentum patellæ; the extensor muscles of the thigh are relaxed, and the deformity of the joint indicates at once the nature of the displacement.

In these cases *Reduction* is always easy; indeed, it is occasionally effected by the unaided efforts of the patient or by a bystander. It may be accomplished by flexing the thigh upon the abdomen, then extending the leg, and, at the same time, by a movement of rotation, replacing the bones in their proper position.

2. The dislocation **Backwards** may be *complete* or *incomplete*. When it is complete, the posterior ligament of the joint and the posterior crucial ligament are torn, the muscles of the ham are stretched, the limb is shortened to the extent of an inch and a half or two inches, and is semiflexed; the head of the tibia can be felt in the ham, and there is a deep transverse depression in front of the joint immediately below the patella.

3. The dislocation of the tibia **Forwards** is of more frequent occurrence

than the last accident. In it, the lower end of the femur is felt projecting into the ham, occasionally compressing the vessels to such an extent as to arrest the circulation through the lower extremity, lacerating the ligaments, and stretching the muscles in this situation. The tibia projects forwards, its head forming a considerable prominence on the anterior part of the knee, with a deep depression immediately above it and the patella, which is rendered more evident by the relaxation of the extensors of the thigh; the leg is usually rotated somewhat inwards or outwards, and there is shortening to the extent of about two inches.

These antero-posterior dislocations are very commonly incomplete. When this is the case, they present the same symptoms, but in a less marked degree, as those which characterize the complete displacements.

In the *Treatment* of these dislocations, extension should be made from the ankle whilst the thigh is fixed in a semiflexed position. When the leg has been drawn down sufficiently, proper manipulation will bring the bones into accurate position; splints must then be applied, means taken to subdue local inflammation, and the joint kept perfectly at rest for two or three weeks, at the end of which time passive motion may be commenced.

Complications.—Dislocations of the knee-joint are more liable to serious complications than those of any other articulation. Not only are the ligaments torn, and the muscles injured, but stretching, and perhaps laceration, of the popliteal vessels, followed by gangrene of the limb, may occur; or the injury may be followed by destructive inflammation of the joint.

Compound Dislocation of the Knee-joint is one of the most serious injuries to which the limbs are liable; the external wound being usually large, ragged, and accompanied by the protrusion of the condyles of the femur, with much laceration of the soft structures in the vicinity of the joint. These are cases that certainly, as a general rule, call imperatively for amputation. Cases, however, have occurred in which the limb has been saved. Hence, if the patient be young, if the vessels of the ham do not appear to have been seriously injured, and if the wound in the soft parts at the same time be not very extensive, nor much bruised, an attempt may with propriety be made to save the joint. In a case of compound dislocation of the knee forwards in a boy, A. White sawed off the projecting end of the femur which protruded through the ham, and, bringing the wound together, succeeded in saving the limb.

Congenital Dislocations of the Knee have been occasionally met with, with displacement of the tibia forwards. Cases of this kind have been recorded by Hilton, Guérin, Barwell, and Godlee. In some it was complicated by absence of the patella. In Barwell's case flexion was extremely limited, but by pushing the tibia backwards it could be carried to a considerable angle, and by fixing it in this position with a plaster-of-Paris-bandage, the dislocation was completely cured at the end of six weeks' treatment.

Subluxation of the Knee, or "internal derangement of the knee-joint," is a more frequent accident than any of those that have just been described. It usually occurs from the patient, whilst walking, striking his toe against or tripping upon a stone, when he is suddenly seized with acute and sickening pain in the knee, often so severe as to cause him to fall. Before doing this, however, he is conscious of having strained or otherwise injured the joint. On examination it will be found semiflexed, the patient being unable to extend the limb properly, and every effort being attended by severe pain; and the edge of

the semilunar cartilage may sometimes be felt projecting under the skin. In the course of a very short time the joint becomes swollen, being distended by synovial secretion; and symptoms of subacute synovitis speedily appear. This accident, originally described by Hey, and since investigated by Sir A. Cooper and others, occurs usually in consequence of the semilunar fibro-cartilage slipping away from under the internal condyle, either before or behind it, so as to bring the surface of the condyle and that of the tibia into direct apposition, but cases have also been recorded in which the displacement affected the external cartilage. The severe pain that is always experienced is owing in all probability to the nipping of the loose folds of synovial membrane that lie within the joint—the so-called mucous and alar ligaments, and also to the great stretching of the ligaments by the partial displacement of the bones.

The *Reduction* may be effected by flexing the joint, and then, when the muscles are off their guard, the patient's attention being directed elsewhere, rapidly extending it at the same time that a movement of rotation is communicated to the leg. The evidence of complete reduction consists in the restoration of the power of extending the articulation. The synovitis that usually follows this injury requires to be treated by local antiphlogistic remedies and rest. No means are known by which the cartilage can be fixed again as firmly as it was before the accident, and in the great majority of cases recurrence of the displacement takes place at intervals. The best means of preventing it is to support the knee either with a laced knee-cap, having a leather stiffener behind, or a flannel bandage firmly applied. Should reduction prove impossible, or should the displacement return immediately, when the patient uses his limb again, it is useless to try to fix the cartilage by prolonged rest. The patient should begin to use his leg freely as soon as the synovitis has subsided, and after a time the displaced cartilage seems to accommodate itself to its new position, and gives no further trouble.

Rupture of the Posterior Crucial Ligament is an accident that occasionally occurs as the result of a violent blow on the anterior aspect of the head of the tibia, such as may be received in a railway-accident when the patient is thrown forwards against the opposite seat. The symptoms are at first effusion of blood and synovia into the injured joint. When this is absorbed, it will be found that the knee is weak, giving way slightly when flexed in walking. When the patient is seated with the knee flexed to a right angle, and the foot firmly planted on the ground, if the tibia be grasped at its upper end and moved backwards and forwards, it will be found to be capable of a slight displacement backwards into the ham. The *Treatment* consists in supporting the knee with a properly fitted apparatus.

The **Head of the Fibula** has occasionally, though very rarely, been displaced by the application of direct violence. Boyer and Sanson have each recorded a case of this kind. One such case has occurred to me in my practice. It happened in a gentleman about 23 years of age, who, in descending an Alpine slope covered with snow, fell with one leg bent forcibly under him, so that he came down, as it were, in a sitting posture. The head of the fibula was thrown back off the articulating surface, and remained permanently in its new situation. The limb was somewhat weakened, so that the patient could not jump, but otherwise he suffered no inconvenience. The tendon of the biceps was very tense; and when I saw the case, some time after the accident, its traction effectually prevented all attempts at reduction.

Dislocations of the Ankle occur in consequence of displacement of the astragalus from the bones of the leg, whilst it continues to preserve its normal connection with the rest of the foot. These dislocations are almost invariably connected with fracture of the lower end of the fibula, or of the inner malleolus. In fact, on looking at the arched cavity into which the astragalus is received, it is evident that this bone can scarcely be displaced laterally without fracture of one side of this arch. In considering these dislocations we must, in accordance with the general nomenclature of similar accidents, in which the distal part is always said to be displaced from the proximal, look upon the foot as being dislocated from the leg, and not consider the tibia as being displaced upon the foot. The direction of the dislocation must consequently be determined by the position into which the articular surface of the astragalus happens to be thrown. It is necessary to explain this, inasmuch as a good deal of ambiguity occurs in surgical writings from the same accident being described differently, according to the view taken of the part displaced. Thus, Sir A. Cooper speaks of the tibia as being dislocated at the ankle; whilst Boyer and others, regarding the foot as the part displaced, have described the same injury in directly opposite terms.

Dislocations of the foot from the bones of the leg may take place in four directions, viz., *to either side, backwards*, or *forwards*. In all cases, the injury appears to be occasioned either by the foot being twisted under the patient in jumping or running; or else by its being suddenly arrested by coming into contact with the ground whilst the body is carried forwards. But these twists or sprains do not necessarily occasion dislocation, and must not be confounded with that accident.

The dislocation **Outwards** is of most frequent occurrence. The inner malleolus projects forcibly against the skin. The deltoid ligament is either ruptured, or the lower end of the inner malleolus broken off; there is a depression above the outer ankle corresponding to a fracture of the fibula; and the sole of the foot is turned upwards and outwards, the inner side touching the ground, whilst the outer edge is turned up. It is, in fact, merely a severe case of Potts' fracture (Fig. 255).

In the dislocation **Inwards,** which is a rare accident, and, according to Sir A. Cooper, much more dangerous than that just described, the fibula is not fractured, but the lower end of the tibia is splintered off, in an oblique manner from within outwards. The outer edge of the sole rests against the ground, and the inner side is turned up.

The *Reduction* of these lateral displacements is readily effected by simple traction on the foot, while the leg is flexed at the knee in order to relax the muscles inserted into the tendo Achillis; leg-splints with lateral foot-pieces must then be put on, or Dupuytren's splint may be applied on the same side as the dislocation, opposite to that on which the eversion of the foot takes place.

In the dislocation of the foot **Backwards,** the deltoid ligament is ruptured, the fibula probably broken in the usual situation, and the tibia thrown forwards on the scaphoid and cuneiform bones; the foot is consequently shortened, the heel rendered more projecting, and the toes pointing downwards.

The dislocation **Forwards**, in which the foot is lengthened, and the tibia thrown upon the upper and posterior surface of the os calcis, behind the astragalus, is an accident so rare as seldom to have been witnessed, although described.

In the *Treatment* of these antero-posterior displacements of the ankle, traction of the foot in a proper direction, the leg being fixed and flexed upon the thigh, will readily be attended by replacement; the application of lateral splints being afterwards sufficient to keep the parts in proper position. Sometimes subcutaneous division of the tendo Achillis is necessary.

Compound Dislocations of the Ankle-joint are serious and by no means unfrequent accidents, the displacement occurring in the same direction and from the same causes as the simple forms of injury.

The *Treatment* of compound dislocations of the ankle-joint must depend to a considerable extent upon the amount of laceration of the soft parts, and the condition of the bones forming the arch of the joint. If the wound in the soft parts be moderate in extent, clean cut, and with little bruising and injury to the bones, an attempt should be made to save the limb. This is to be done by the assiduous use of antiseptics. There is no class of joint-injuries in which this method has been attended by better success than in these. The details should be carefully attended to as given at page 492 *et seq.* Should antiseptics not be at hand, the case must be treated on ordinary principles, viz., by rest on a splint, and application of ice or cold evaporating lotions. In many instances this plan will suffice, and the patient will recover with a stiff but useful limb, the joint being only partially ankylosed.

If, however, the bones be projecting and comminuted, and the soft parts extensively lacerated, the question of amputation will necessarily arise. In many cases, the operation may be avoided by adopting the treatment recommended by Hey, of sawing off the malleoli, removing splinters of bone, and supporting the limb at the same time upon a M'Intyre's splint. If the joint be still more seriously injured, the posterior tibial artery torn, or the foot greatly contused, and especially if the patient be aged and his constitution shattered, recourse should be had to primary amputation. I believe that the disinclination on the part of Surgeons to amputate in these cases, greatly owing to the strong expression of opinion by Sir A. Cooper in favour of the attempt to save the limb, has in many cases been carried to such an extent as seriously to add to the patient's danger. Secondary amputation may be rendered necessary in consequence of gangrene, erysipelas, or extensive suppuration.

Dislocations of the Astragalus.—The astragalus is occasionally displaced from its connection with the bones of the leg above, and with those of the tarsus below, being thrown either *forwards* or *backwards*. The displacement forwards happens far more frequently than that in the opposite direction. In the dislocation **Forwards**, the head of the bone may be thrown either *outwards* or *inwards*; but I do not think there is any evidence to show that complete lateral dislocation of this bone can occur irrespective of displacement forwards: the so-called *lateral* dislocations being displacements of the bone forwards, with twists to one or the other side. The dislocation *forwards*, with lateral inclination, may either be *complete* or *incomplete*. When it is *complete*, the bone is thrown out of its bed on the calcaneum, and separated from its connections with the malleolar arch above and the scaphoid in front, being forced in front of the tarsus, and lying upon the scaphoid and cuneiform bones. When the dislocation is *incomplete*, the head is separated from the scaphoid, and is thrown upon it, or on the external cuneiform or cuboid bones, the body of the astragalus maintaining its connections with the malleolar arch and os calcis. The dislocation **Backwards** is, I believe, always *complete*. In the luxation backwards

there is no rotation of the bone, which is thrown directly behind the tibia, in the space between it and the tendo Achillis.

These dislocations invariably happen from falls upon or twists of the foot; more particularly when it is extended upon the leg. When the foot is in this position, the lower end of the tibia either breaks off on the application of sufficient violence, or the head of the astragalus is forced out of the cavity of the scaphoid and its bed on the os calcis; the particular kind of displacement that occurs depending upon the direction in which the force is acting and in which the foot is twisted. And, as the foot is more frequently twisted inwards, the head of the astragalus is thrown outwards. Dislocation of the astragalus differs from dislocation of the foot in this—that when the foot is dislocated, the astragalus, though thrown out from under the malleolar arch, preserves its connections with the rest of the tarsus; whilst these are always broken through when the astragalus is the bone dislocated, even though it have not completely escaped from between the malleoli.

The dislocation of the astragalus *forwards*, with twist of the bone *inwards*, is said to be of most common occurrence: I have, however, more frequently witnessed that form of accident in which the bone is thrown somewhat *outwards* as well as forwards. In either case the displaced bone forms a distinct tumour upon the instep, in the outline of which the form of the astragalus can be distinctly made out. Over this, the skin is so tightly drawn as often to appear to be on the point of bursting. When the bone is thrown somewhat inwards, the foot is turned outwards, and the internal malleolus projects distinctly. When the astragalus is thrown *outwards*, displacement of the foot inwards, with great projection of the lower end of the fibula, takes place. In some cases, fracture of the neck of the astragalus is conjoined with these dislocations; and not uncommonly the luxation is compound from the very first, or speedily becomes so if left unreduced, in consequence of the sloughing of the skin which covers the anterior surface of the bones, the exposed portion of which undergoes necrosis, and perhaps eventual exfoliation.

The dislocation *backwards*, into the hollow under the tendo Achillis, is rare, there being but seven recorded instances of this accident. In the majority of these there was displacement of the bone *inwards*, as well as backwards. In these cases the diagnosis is easy, as the bone forms a distinct prominence, which can be felt under the tendo Achillis.

In many cases the dislocation of the astragalus is not altogether complete, a portion of the bone still intervening between the under surface of the tibia and the upper surface of the os calcis.

Treatment.—The reduction of the dislocation *forwards*, whether attended by lateral displacement or not, varies greatly in facility; in some instances being effected with the greatest possible ease, in others being attended by almost insurmountable difficulties. This difference depends, I think, on whether the dislocation is complete or not. When the astragalus is not completely thrown from under the arch formed by the bones of the leg, a portion of it being still entangled between their articular surfaces and that of the calcaneum, it may usually be readily reduced by relaxing the muscles of the calf, and pushing the bone back into its proper position. But when the astragalus is completely dislocated, the upper surface of the calcaneum is drawn up under the arch of the malleoli by all the strength of the muscles that pass from the leg to be inserted into the foot. In these circumstances, in order that reduction may take

place, it is necessary first of all to separate the articular surfaces to such an extent as to admit of the astragalus being pushed back into its socket: this is almost impossible, owing to the great perpendicular thickness of this bone, to the extent to which it is consequently necessary to draw down the foot, and to the little purchase that can be obtained on it. In such cases, reduction has been greatly facilitated by the division of the tendo Achillis, by which simple operation the whole strain of the muscles of the calf is taken off.

If reduction be still impracticable, and the bone continue unreduced and irreducible on the dorsum of the foot, what should be done? Two courses present themselves to the Surgeon; either at once to cut down upon the astragalus and to remove it; or to adopt a palliative treatment—to put the limb at rest on a splint, to apply evaporating lotions, and to wait the result, acting according to circumstances as they develop themselves. In some rare cases, the displaced astragalus has given rise to comparatively little inconvenience; but this can seldom be expected. If the dislocation have been in the direction forwards, the skin will usually slough, and then a portion of the exposed osseous surface, which will probably necrose, may be excised, or the whole of the astragalus may be dissected out by freely exposing it, and severing its ligamentous attachments; the patient recovering with a somewhat stiffened, but still useful joint. This plan appears to be safer than excising the bone in the first instance, so soon as the dislocation has been found to be irreducible. The operation of excising the dislocated astragalus may be greatly facilitated by the exsanguination of the foot and leg by means of Esmarch's elastic bandage. The tissues are pale and the operation is bloodless, so that the Surgeon can see exactly what he is cutting, and where.

In luxation *backwards*, the bone has not hitherto to my knowledge been reduced, except in one case which occurred in University College Hospital, and in which the tibia and fibula were also fractured. It is by no means improbable that subcutaneous division of the tendo Achillis may in future enable the Surgeon to effect reduction. The result is, however, satisfactory, even though the bone be not reduced, the patient recovering with a useful foot. If the dislocation be left unreduced, the softs parts covering the bone may slough, as happened in a case recorded by R. C. Williams of Dublin, in which the bone was consequently extracted.

In **Compound Dislocation of the Astragalus** (Fig. 309), the rule of practice must depend upon the extent of injury. If the integuments have merely been rent in consequence of the outward pressure of the displaced bone, an attempt must be made to reduce the dislocation by the aid, if necessary, of the division of the tendo Achillis; and, if this be effected, to close the wound by the first intention. If the bone be comminuted as well as dislocated, the proper practice will be to remove the loosened fragments, and to dress the wound antiseptically, allowing it to heal by granulation. If the bone be irreducible, it is a question whether it should be left or dissected out. If it be left, the wound in the integuments will certainly extend by sloughing, the bone will inflame and become necrosed, exfoliating in fragments, and the patient will recover only after a prolonged, tedious, and dangerous course of treatment. In these circumstances, therefore, it appears to me that the simpler and safer plan both to limb and life consists in enlarging the wound in proper directions, so as to dissect out the irreducible astragalus, and then bringing the articulating surfaces into contact, dressing the parts antiseptically,

and trusting to the formation of a new joint between the tibia and the os calcis. So, also, if a simple dislocation of the astragalus become compound in consequence of the sloughing of the superjacent tense integuments, the exposed and necrosing bone should be removed in part or in whole, according to the circumstances of the case. If together with the dislocation of the

Fig. 309.—Dissection of Foot in Compound Dislocation of Astragalus outwards.

astragalus, the foot be extensively crushed, amputation may be required either at the ankle-joint or at some convenient part of the leg.

Dislocations of the other Tarsal Bones are of extremely rare occurrence. Most of these bones, however, have been found luxated at times.

The **Calcaneum** and **Scaphoid**, carrying with them the rest of the foot, are sometimes dislocated from the astragalus, which is left *in situ* under the malleolar arch. In these dislocations the bones may be displaced in either lateral direction—outwards or inwards. The *Treatment* consists in the flexion of the leg and attempts at reduction by extension of the foot in the ordinary way. If moderate extension fail in effecting reduction, Pallsel has recommended division of the tendo Achillis, and, if necessary, of the posterior tibial tendon, as a means of facilitating this, on the same principle as in dislocation of the astragalus.

The **Calcaneum** has been dislocated laterally from its connection with the cuboid in consequence of falls from a height, the sufferer alighting upon his heel. Chelius mentions a case in which this bone was dislocated by the effort of drawing off a tight boot. *Reduction* seems to be readily effected by relaxing the muscles, and pressing the bone back into its proper position.

The **Scaphoid** and **Cuboid Bones** have been dislocated upwards, in consequence of a person jumping from a height and alighting upon the ball of the foot. In these instances the limb is shortened and curiously distorted, the toes pointing downwards, and the arch of the instep being increased so as to resemble closely enough the deformity of club-foot. *Reduction* may be effected by drawing and pressing the parts into position.

The **Internal Cuneiform Bone** has occasionally been found to be dislocated. Sir A. Cooper mentions an instance of the kind. If reduction be not effected by pressing the bone into its position, no great evil appears to result to the patient, the motions of the limb not being seriously interfered with.

Sometimes the tarsal joints are extensively torn open without any one bone being distinctly dislocated. I have seen this happen to a young man who caught his foot between the spokes of a revolving wheel; the foot was

violently bent and twisted, and all the tarsal joints more or less torn open, so as to necessitate amputation.

Dislocation of the Metatarsal Bones, though excessively rare, from the manner in which these bones are locked into the tarsus, and retained by short and strong ligaments, yet occasionally occurs. Instances are recorded by Dupuytren and Smith: Liston mentions a case of luxation of the metatarsal bone of the great toe from direct violence; and Tufnell records a case of luxation downwards and backwards of the inner three metatarsal bones, from a fall upon the leg by a horse rolling on its rider. Two cases have occurred in my practice, in one of which, by the pressure of a "turn-table" on a railway, the *outer* three metatarsal bones were dislocated downwards. In the other, in consequence of a horse falling and rolling on its rider, there were a compound dislocation of the first and a simple dislocation of the fourth metatarsal bone. The question of amputation will always present itself in these cases, and must be determined on general principles, by the age of the patient, and the extent of injury to the soft parts.

Luxations of the *Phalanges of the Toes* but rarely happen, and present nothing special in nature or treatment.

INJURIES OF REGIONS.

CHAPTER XXIV.

INJURIES OF THE HEAD.

Injuries of the Head are among the most important subjects that can engage the Surgeon's attention. Their importance is derived not so much from the injury of the scalp and skull, as from the implication of the brain and its membranes, and the results which are thereby produced, in many cases directly, and in others indirectly and remotely, owing to the anatomical connections and consequent close pathological sympathies that exist between the external and internal structures of the head. In consequence of this tendency to cerebral complication, it is of the first moment in practice to study these injuries as a whole, with special regard to the affections of the encephalon that are produced by them, and from which the injury of the scalp and the fracture of the skull derive the greater part of their importance. It is therefore necessary, in the first instance, to be acquainted with the nature and treatment of the principal forms of cerebral affection that supervene upon these accidents, before we proceed to study the injuries themselves.

CEREBRAL COMPLICATIONS OF INJURIES OF THE HEAD.

These may be primary or secondary. The brain is subject to three principal **Primary States of Functional Disturbance** arising from injury; viz., 1. Concussion, 2. Compression, and 3. Cerebral Irritation. Any one of these may be followed by, or be complicated with, subsequent inflammation, that derives peculiar characteristics from the conditions with which it is associated, and from the injury by which it is occasioned.

In describing these different conditions, we are compelled to define the symptoms that characterize them more distinctly than is the case in actual practice, where they are not so clearly individualized, but become merged together to a considerable extent.

1. Concussion of the Brain.—Concussion, or stunning, appears to be a shock communicated to the head from the application of such external violence as will produce commotion of the substance of the brain, or interfere with the circulation through it; in consequence of which its functions become suspended, usually in a slight and transitory degree, but occasionally to such an extent that the patient does not rally for many hours from the depressed state into which he is thrown, and perhaps sinks without recovery.

The **Pathology** of concussion of the brain is very obscure; so much so, in fact, that the term must be considered to have rather a clinical than a pathological significance. The reason of this is obvious;—few people die from simple concussion. In those cases in which death has occurred from other causes during a state of cerebral concussion, it has been found that the disturbance of the functions of the brain constituting concussion has been due to actual though slight lesion of its substance. In some cases, the vessels of the brain and its membranes have been congested. In others, again, portions of the cerebral substance, varying in size from minute points to patches an inch or more in diameter, have been disintegrated and more or less ecchymosed. In the more severe and fatal cases of concussion of the brain, the cerebral substance is ecchymosed in a punctiform manner or disorganized to a great extent; in fact, in these cases the characteristic signs of contusion of the brain become apparent.

The **Signs** of concussion vary according to the severity of the injury to the brain. In the slighter cases, the patient may merely feel giddy and confused for a few minutes. In others, consciousness is not affected, but the patient feels faint and weak, and is unable to stand. In the more severe form—in that degree, indeed, which usually accompanies any severe injury of the head—the surface of the body becomes cold and pale; the temperature falls to 97° F., or even to 96° F., if the accident has occurred in cold weather; the sufferer is motionless and insensible, or answers only when spoken to in a loud voice, relapsing again into speedy insensibility, or rather semi-consciousness; the pulse is feeble; the respiration is slow and shallow; the pupils are usually contracted, but may be dilated, and generally respond to the action of light, and the sphincters are usually relaxed; the limbs are flaccid, and muscular power is impaired or lost. After this condition, which is the first stage of concussion, has lasted for a few minutes or hours, according to the severity of the shock, the second stage comes on; the circulation gradually re-establishing itself, the pulse becoming fuller, and the surface warmer. As reaction becomes fully established, the temperature rises slightly above the normal standard, the degree of elevation being in proportion to the severity of the concussion. In slight cases the thermometer will rise to 99° F. or 99·5° F., while after more severe injuries it may reach 100° F., beyond which point it seldom passes in cases of simple concussion. About this time the patient very commonly vomits; the straining accompanying this effort appears to be of service in stimulating the heart's action, and driving the blood with more vigour to the brain, thus tending to restore its functions; and we accordingly find that, after vomiting, the sufferer quickly rallies. In the more severe cases, the symptoms that have just been described are so strongly marked that the patient appears to be moribund—prostration of all nervous and physical power being complete, the surface being cold and clammy, as in death, the eyes glassy, the pupils either contracted or widely dilated, the pulse scarcely perceptible and intermittent. In this state the patient may lie for hours, recovery being slow, and the concussion merging into some other and perhaps more serious affection of the nervous centres; or, indeed, in some cases, speedily terminating in death, apparently by failure of the heart's action. But it may truly be said, that every case of concussion in which unconsciousness, though but momentary, has been produced, is a most serious one. Any remote evil consequence in the form of secondary cerebral disease may possibly ensue, if

once the brain-substance have been so severely shaken as to render the patient unconscious, even though the insensibility last but a few minutes. All such cases require to be closely watched and carefully managed for months after the injury.

The **Terminations** of concussion are various. We have already seen that in some cases this affection may speedily end in complete recovery; although slight headache, some degree of giddiness, confusion of thought, and inaptitude for mental occupation, may last for a few days before the mental powers are completely re-established. In these it is probable that no coarse lesion of the brain substance has taken place. In other cases, the concussion may rapidly terminate in death, and in these it will always be found that distinct contusion or laceration of the brain substance has occurred. Between these conditions there are several intermediate states. Thus, recovery may be complete, but a permanently irritable state of brain may be left; the patient, though capable of the ordinary duties of life, becoming readily excited by slight excesses in diet or in the use of stimulants, or by mental emotion, though not of an inordinate intensity. Individuals thus affected, suffering from a preternaturally irritable brain, sometimes die suddenly in the course of a few months, or a year or two, after the receipt of the injury.

In other cases the recovery continues incomplete; although the patient may be enabled to follow his usual occupation, and to mix in the ordinary business of life, yet his state is precarious, the brain being liable to the occurrence of inflammatory disease on the slightest exciting cause. In such cases as these, there is frequently a certain degree of impairment of mental power; the memory failing either generally or in certain important points, as with reference to dates, persons, places, or language. The speech is perhaps indistinct and stuttering. Impairment of vision is a very common consequence of these injuries. Asthenopia, with perhaps squinting or paralysis of the eyelid, may be left. The hearing may be impaired, or noises of various kinds set up in the ears. Epileptiform convulsions occasionally occur; sometimes, as the patient is recovering his consciousness, he may be seized with a severe fit; but more commonly the convulsions do not come on as a primary consequence, but rather as a remote secondary result of the brain-injury. There may be diminution or loss of muscular and of virile power, especially, as Hennen observes, when the injury has been inflicted upon the back of the head; and Holberton has noticed that, when the medulla oblongata has been injured, the pulse may continue preternaturally slow—an observation which I have had several opportunities of confirming in injuries both of the medulla, the pons Varolii, and the crura cerebri. For these symptoms to occur, it is by no means necessary that the original local injury should have been severe. In some cases, the whole nervous system appears to be jarred and concussed without any wound or apparent sign of external injury to the head. At first, the symptoms of concussion are but slight, perhaps even none are apparent, and the sufferer congratulates himself on his escape; but gradually impairment of nervous power, manifesting itself in one or other of the ways just mentioned, comes on, and the health continues broken through life.

In other cases, again, the symptoms of concussion may gradually terminate in those of compression; and not unfrequently the reaction that comes on, passing beyond the bounds that are necessary for the re-establishment of the healthy functions of the brain, terminates in inflammation. Hippocrates

truly observed, that no injury of the head is too trivial to be despised, or too serious to be despaired of.

2. Compression of the Brain.—This is a common condition in injuries of the head, arising from a great variety of causes :—from the pressure of a portion of bone, of extravasated blood, of inflammatory exudation, or of pus formed within the skull, or from a foreign body lodged there. In whatever way occasioned, however, the symptoms, although presenting some differences, are tolerably constant. The patient lies in a state of coma, stupor or lethargy, being paralysed more or less completely, heavy and drowsy, or insensible, not answering when spoken to, or only when addressed in a loud voice, and perhaps shaken at the same time. The breathing is carried on slowly and deeply, with a stertorous or snoring noise, and usually a peculiar blowing of the lips. The stertor appears to be owing to paralysis of the velum pendulum palati, which, hanging down as an inanimate curtain, is thrown into vibrations during expiration by the passage of the air across it ; the distension of the cheeks and blowing of the lips are due to the muscular paralysis of these parts. One or both pupils are dilated and insensible to light ; the pulse is full, often slow—in fact, a full, slow, laboured pulse is one of the most marked features in these cases ; the fæces pass involuntarily from paralysis of the sphincter ani, and the urine is retained from paralysis of the bladder ; the skin may be cool, but in many cases, on the contrary, is rather hot and perhaps perspiring ; the temperature may rise to 106° F. Not unfrequently during this condition of stupor violent fits of convulsions may occur. This state of coma may become complicated by symptoms of inflammation ; and, unless the cause that produces the compression be removed, it usually terminates speedily in death, the patient gradually sinking into more complete unconsciousness, and dying in an apoplectic condition. In other, but much rarer cases, the coma may continue almost an indefinite time, for many weeks or even months, until the compressing cause is removed, when the patient may recover consciousness, and the symptoms disappear.

The **Diagnosis** between *concussion* and *compression* has been sufficiently indicated in the preceding description not to require special mention here. But it must be remembered that, in many cases, one state merges into the other, so that the symptoms are not so distinctly marked as has been indicated ; and they are more especially obscured when associated with inflammation.

With regard to compression it may be broadly stated that whenever the symptoms follow an injury to the head within twenty-four hours they are due to the pressure of fragments of bone in depressed fractures, foreign bodies in penetrating fractures, or extravasated blood in simple injuries. Compression from inflammatory exudation does not occur till the third day at the earliest.

3. Cerebral Irritation.—The third form of primary cerebral disturbance which is met with in injuries of the head, differs very remarkably from both the preceding. The patient presents symptoms neither of concussion nor of compression, nor is there any combination of the phenomena characterizing these two states ; but the symptoms are altogether peculiar. For convenience of description, they may be divided into two groups, the *bodily* and the *mental*.

The **Bodily Symptoms** are as follows. The attitude of the patient is peculiar and most characteristic :—he lies on one side and is curled up in a

state of general flexion. The body is bent forwards, the knees are drawn up on the abdomen, the legs bent, the arms flexed, and the hands drawn in. He does not lie motionless, but is restless, and often, when irritated, tosses himself about. But, however restless he may be, he never stretches himself out nor assumes the supine position, but invariably maintains an attitude of flexion. The eyelids are firmly closed, and he resists violently every effort made to open them; if this be effected, the pupils will be found to be contracted. The surface is pale and cool, or even cold. There is no heat of head. The pulse is small, feeble, and slow, seldom above 70. The sphincters are not usually affected, and the patient will pass urine, when the bladder requires to be emptied; there may, however, though rarely, be retention.

The **Mental state** is equally peculiar. Irritability of mind is the prevailing characteristic. The patient is unconscious, takes no heed of what passes, unless called to in a loud tone of voice, when he shows signs of irritability of temper or frowns, turns away hastily, mutters indistinctly, and grinds his teeth. It appears as if the temper, as much as or more than the intellect, were affected in this condition. He sleeps without stertor.

The course taken by these symptoms is as follows. After a period varying from one week to three, the pulse improves in tone, the temperature of the body increases, the tendency to flexion subsides, and the patient lies stretched out. The mental state also changes. Irritability gives way to fatuity; there is less manifestation of temper, but more weakness of mind. Recovery is slow, but, though delayed, may at length be perfect; although in these, as in all other cases of cerebral disturbance, ulterior consequences may be manifested.

This form of cerebral disturbance may, from the peculiar irritability that characterizes it, be with propriety termed *cerebral irritation.*

The symptoms that have just been described usually follow blows upon the temple or forehead, and probably in many cases may arise from, or are associated with, lacerations of the cerebral substance, more especially of the grey matter.

Contusion or Laceration of the Brain.—The substance of the brain is very frequently contused or lacerated by blows upon the head. The degree of injury varies from a mere superficial bruising indicated merely by a few dotted points of extravasated blood in the grey matter, to extensive disintegration of the brain-substance over an area of the size of half-a-crown or larger, in which the broken down brain-tissue is indistinguishably mixed up with blood-clots. Laceration of the brain is fully described under Wounds and Injuries of the Brain Substance, p. 739. It is sufficient here to say that the symptoms to which it gives rise are very various according to the part injured and the extent of the injury. More or less contusion or laceration of the brain substance is probably an invariable accompaniment of all those cases which we speak of clinically as severe concussion of the brain, and more especially of those which are followed by some definite impairment of one or more of the central functions. The hæmorrhage from the torn brain substance is one of the most frequent causes of compression, and cerebral irritation may be always regarded as indicative of actual injury of the cortical tissue. Laceration of the brain, with arachnoid hæmorrhage consequent upon it, or with secondary inflammatory changes round the injured spot, is one of the most frequent causes

of convulsions in head injuries. The special features which mark lacerations of certain parts will be described more fully later on.

Effects of Cerebral Injury on the Mental Powers.—The mental condition of patients who are recovering or who are supposed to have recovered from head-injury, is one that deserves attentive consideration. It will frequently be found that the mental powers are weakened, either generally or in one special direction.

The memory will often be found to be weakened in a very remarkable manner on the recovery of the patient from that unconsciousness which results from severe concussion. Not only is there a complete blank as to all that occurred during the period of the unconsciousness, but the memory may be lost for those events which immediately preceded it. Thus a driver will recollect his horses taking fright; but he will never be able to recall to his recollection the various events that occurred before he was thrown from his box, and received that blow on the head which produced concussion of the brain and rendered him unconscious—events which had certainly produced impressions upon the brain before it was injured—impressions which were permanently obliterated by the concussion of the cerebral substance. The chain of memory is broken abruptly at some occurrence—often of a very trivial character—antecedent to the accident, and the gap then left can never be filled by any subsequent effort on the part of the patient.

The memory may be impaired in other ways, as for words, persons, or dates. The mind cannot grasp a subject or carry out a continuous train of thought, and is incapable of fixed attention or reasoning. Delusions of various kinds may occur, especially in connexion with the mode of occurrence of the accident. I have known a patient to give the most consistent and detailed accounts of the mode in which his head was injured, varying them from day to day—every one being false, but believed in by the patient at the time. The patient could be led, by a process of questioning and suggestions combined, to give almost any version that the interrogator desired ; and this with great circumstantiality of detail. This is a matter of much interest and importance in a medico-legal aspect, as it is evident that an individual who has sustained a severe injury of the head might, in perfect good faith, give an entirely false account of the mode of infliction of the injury, by which an innocent person might be seriously compromised.

The **Secondary Consequences** of injury of the brain are the results of inflammation either diffused or circumscribed. As in all other injuries the character of the inflammation is materially influenced by the admission or exclusion of air. In compound fractures of the skull septic meningitis is a common and most fatal complication; in simple fractures diffuse meningitis is of very rare occurrence. So also in open wounds of the brain, spreading inflammation of the cerebral substance is of common occurrence, giving rise to suppuration with extensive destruction of the tissue of the hemisphere; while in lacerations without open wound, although there is frequently some inflammation and softening round the injured spot, it seldom spreads very far and rarely terminates in suppuration.

1. Traumatic Encephalitis.—Inflammation of the brain and its membranes from injury is an affection of great frequency and of corresponding importance. It is apt to supervene on all injuries of the head; though the liability to it necessarily increases with the severity of the accident. This

inflammation of the brain and its membranes may set in with great intensity, the symptoms being strongly marked; in other instances it gradually creeps on in a slow and insidious manner, not attracting attention until it has given rise to some severe and ulterior consequences, as effusion or suppuration, when its symptoms become so mixed up with those of compression and irritation, as to make the exact diagnosis of the patient's condition far from easy. The period at which symptoms of inflammation of the brain may manifest themselves, after an injury of the head, varies greatly. In some instances they set in almost immediately the patient has recovered from the effects of the concussion; the reaction from this state gradually assuming an inflammatory character. Septic meningitis and encephalitis usually commence on the second day, and the symptoms reach their maximum intensity by the third or fourth day. In other cases it is not until after several days that inflammation declares itself; and again, it sometimes happens that the inflammatory affection does not supervene for weeks or months: but then, occurring perhaps under the influence of comparatively trivial causes, it may destroy the patient.

Pathological Changes.—After death, we find usually both the brain and its membranes inflamed. The arachnoid is, however, the structure that appears principally to suffer, especially in septic meningitis, being thickened, so as to become milky and semi-opaque. Adherent lymph of a greenish-yellow colour and opaque purulent appearance, covers one or both hemispheres of the brain, being deposited chiefly in the subarachnoid space and in largest quantity at the seat of the injury, but not unfrequently extending across and into its fissures, occupying especially the depressions about its base. The vascularity of the brain and its membranes is greatly increased; the arachnoid being reddened in patches, and the vessels visible in the pia mater becoming turgid and very numerous, forming a vascular network over the surface of the brain. The sinuses also are distended with blood; the cerebral substance when cut into exhibits an increase in the number of red points; the grey matter is redder than natural, often presenting a somewhat rosy hue; and the ventricles are filled with reddish semi-turbid serum, a large quantity of which is effused about the base of the brain. In some of the more advanced cases, inflammatory softening of the cerebral substance may occur.

Symptoms.—In considering the symptoms of traumatic encephalitis, it is useless to endeavour to make a distinction between the inflammation of the brain and that of its membranes; the two structures being always more or less implicated at the same time. The most practical division of this disease following injury, is into the *acute* and the *chronic* or *subacute encephalitis.*

Acute Encephalitis usually comes on within eight-and-forty hours of the infliction of the injury. The patient complains of severe, constant, and increasing pain in his head; the scalp is hot, the carotids beat forcibly, the pupils are contracted, the eyes intolerant of light, and the ears of noise; the pulse is full, vibrating, and bounding; and wakefulness, with delirium, usually of a violent character, speedily comes on. All the symptoms of severe pyrexia set in at the same time. The temperature rises rapidly, usually reaching 103° F., or more, by the third day.

Under active and proper treatment, this condition may gradually subside until the health is re-established, but more commonly the symptoms of inflammation merge into those of compression—the delirium being replaced

partly or entirely by stupor, from which the patient is roused with difficulty, the pupils gradually dilating, the breathing becoming heavy and stertorous, the pulse sometimes continuing with its former rapidity, at others becoming slow and oppressed. The skin is hot but clammy; the patient falls into a heavy, dull, unconscious state, which alternates with convulsive twitchings or jerkings, and occasional delirious outbreaks. As death approaches, the sphincters relax, the pulse becomes more feeble, the surface cooler, the coma more intense and continuous, until the patient sinks from exhaustion and compression conjoined. In cases of this kind, pus may be found upon the surface or within the substance of the brain, in one case being diffused, in the other collected into a more or less distinctly circumscribed abscess. In other cases, again, the symptoms of compression appear to be induced by a thick layer of lymph lying upon the surface of the brain, or by a quantity of serous fluid being poured out into the ventricles and about the base.

Chronic or **Subacute Encephalitis** is the most interesting and important variety of inflammation following injuries of the head. It may come on a few days after the infliction of the injury, or not until months have elapsed. It may arise from accidents that implicate simply the skull, as well as from those that directly affect the brain and its membranes. The patient in many cases has apparently recovered entirely from the accident, though in others it will be found that some one symptom indicative of the brooding mischief still continues, such as headache, or impairment of sight or of hearing. Occasionally, the coming mischief is foreshadowed by unusual irritability of temper, by loss of mental vigour, or by some other functional disturbance of the brain. In such cases, the subacute encephalitis may suddenly come on, ushered in perhaps by an aggravation of the persistent symptom, or by an epileptic fit. In other cases, the symptoms set in suddenly without any warning, but usually with much intensity, and speedily prove fatal.

The *Symptoms* of subacute encephalitis, when it has fairly set in, consist of those of inflammation, irritation, and compression of the brain conjoined; in some cases one, in other instances another, of the conditions appearing to predominate. The symptoms consist of pain in the head with heat of the scalp, and either dilatation or contraction of the pupils, occasionally one being dilated and the other contracted. Squinting, intolerance of light, delirium, moaning, or screaming, unconsciousness, with convulsive twitchings of the limbs and face, commonly occur with the ordinary symptomatic fever; and lastly, symptoms of coma, rapidly terminating in death.

In the subacute encephalitis, the same appearances are very generally found after death, as in the more acute form of the affection; but commonly the arachnoid membrane is principally affected. So constantly is this the case, that some Surgeons have proposed, and not altogether with injustice, to apply the term *arachnitis* to this form of traumatic encephalitis, looking upon the inflammation of the arachnoid as the principal lesion.

2. Intracranial Suppuration.—This may be of three distinct kinds:—*a.* Subcranial; *b.* Intrameningeal; *c.* Cerebral.

a. The **Subcranial** form consists in the deposit of pus between the skull and the dura mater. It occurs always at the point struck, and is limited or circumscribed. It is never the result of *contrecoup*.

Three conditions may lead to this variety of intracranial suppuration.

a. A blow on the head which, with or without wound of the scalp or fracture

of the skull, causes a separation of the dura mater from the bone, leaving a cavity in which inflammatory effusions and eventually pus collect.

β. A blow on the head causing necrosis of the bone, either by simple severe contusion, or by detaching it from the dura mater and stripping off the pericranium—thus disturbing its vascular connections, and so giving rise to suppuration under the injured portion of bone.

γ. The irritation of splinters of the inner table in cases of ordinary depressed or of punctured fractures of the skull, causing chronic inflammation of the dura mater and eventual suppuration. In these cases it is often found associated with one or both of the next varieties.

b. The **Intrameningeal** form consists in the accumulation of pus, or of greenish puriform lymph, in the cavity of the arachnoid, or in its deposit in the pia mater. It is usually widely diffused, most generally beneath the part struck; but sometimes on the opposite side of the head, usually more towards the vertex than in any other part. It most commonly occurs as a result of open wounds implicating the brain and its membranes, or of compound fractures of the base of the skull. It may occur also in patients who are suffering from pyæmia arising from some other injury complicating that to the brain itself.

c. The **Cerebral** form is usually met with as a distinct circumscribed abscess in the white substance of the hemispheres, often associated with the last variety, and occurring in individuals of unhealthy habit of body. It may occur :—1. At the seat of injury ; 2. By *contrecoup* ; or, 3. It may be the consequence of the lodgment of foreign bodies in the brain.

The formation of pus within the skull is a sequela of much interest in injuries of the head ; and an endeavour has been made, especially by Pott, to lay down rules by which its occurrence may be accurately determined. Thus it has been said that if, during the continuance of encephalitis, fits of shivering come on, followed by the gradual supervention of coma, which slowly becomes more and more complete, whilst the constitutional symptoms of inflammation do not subside ; and if, at the same time, a puffy swelling form upon the uninjured scalp, or the wound, if there be one, become pale and cease to discharge, the pericranium separating from the bone, which is seen to be yellowish brown and dry, an abscess will have formed under the skull ; and further, that in all probability its seat will correspond to these changes in the scalp and pericranium, which are due to the bone having lost its vitality by being separated from the dura mater by the subjacent abscess.

In many cases, doubtless, this progression of constitutional symptoms, accompanied by the two local signs just mentioned, has afforded proof of the existence of intracranial suppuration. It but seldom happens, however, that the signs attending the formation of pus within the skull occur in the distinct order and with the degree of precision above stated. In the great majority of cases, the Surgeon can only suspect the presence of pus from the symptoms of inflammation terminating in paralysis or coma. Still he cannot say with certainty that pus has formed, for the coma may arise from the pressure of other effusions : but if the puffy swelling of the scalp or the separation of the pericranium occur, with exposure of dry and yellow bone, with hemiplegia on the opposite side, then he may feel himself justified in giving a more positive opinion as to its existence in some situation within the cranial cavity, probably beneath or in the immediate neighbourhood of the part thus affected.

In some cases of abscess examination of the eye with the ophthalmoscope has shown the presence of optic neuritis similar to that met with in tumour of the brain, but this has not been sufficiently constant to render it of any real value in diagnosis; and, on the other hand, it may be present after an injury without suppuration having taken place. Occasionally, as will be seen hereafter, the situation of the pus may be recognised by the effect produced on the cortical centres.

Pyæmia, with its characteristic visceral secondary abscesses, is by no means an unfrequent complication of injuries of the head. It may occur as a consequence of any lesion of the scalp, skull, or brain, in which the patient survives sufficiently long for the development of the characteristic phenomena of this disease. Hence it is chiefly after the slighter forms of cerebral injury that pyæmia and secondary abscesses have been met with; occasionally after wounds of the scalp, rarely after those of the brain or its membranes, but more commonly, and indeed not unfrequently, after injury of the skull, more especially after severe contusion of the bone without fracture.

The sequence of pathological phenomena in these cases is the same that is observed in all in which pyæmia follows injury or wound of the osseous structures. The part of the bone that is struck usually necroses; inflammation and suppuration are set up in the surrounding portions of the skull; the cancelli of the diploë become filled with pus; its veins, which are large, inflame, and become the media of transmitting septic material to the general circulation; the ordinary constitutional symptoms of pyæmia develop, and secondary abscesses eventually form in the lungs, liver, and joints, with effusions into the serous cavities, more particularly those of the pleura and pericardium. The older writers on Surgery had noted and had marvelled at the strange phenomena of hepatic abscess following slight head-injuries, and had generally overlooked the occurrence of secondary deposits in other organs and structures. More modern investigation has shown that these abscesses are pyæmic, that they are a part of a general infection of the system, and that they are almost invariably accompanied by pulmonary abscesses: indeed, it is these and not the hepatic that are the common consequences of pyæmia resulting from cerebral injury. Of eighteen cases, P. Hewett found the lungs studded with abscesses in thirteen, and the liver in three; and of these three, in one case only was the liver alone affected. It has been supposed by some that intracranial suppuration is a necessary precursor of these secondary abscesses: that it frequently co-exists is undoubted—we often meet with pus in these cases between the dura mater and the contused bone: but to suppose that it is a necessary concomitant is an error. I have seen cases in which the most extensive secondary deposits were found in the lungs, liver, joints, &c., but in which not a drop of pus existed in the interior of the skull in any part; but I have never seen a case in which the diploë around the injured bone did not contain pus, sometimes diffused through its cells, sometimes filling its venous sinuses.

When intracranial suppuration co-exists with secondary pyæmic deposits, the symptoms of the two conditions become so mixed up as to lead to considerable difficulty in diagnosis; but when the intracranial suppuration is not established, there may be a complete absence of all cerebral disturbance, whilst the alternating rigors and heat of pyæmia, the oppressed breathing, or the hepatic tenderness, with hiccup or recurring sickness, and articular

tenderness, give unmistakable evidence of the formation of secondary abscesses.

The prognosis of these cases is necessarily most unfavourable. I doubt much whether recovery is possible when once pyæmia has advanced to the formation of secondary visceral abscesses.

TREATMENT.—The treatment of these various cerebral injuries, and of their concomitant affections, is one of the most important and difficult subjects that can arrest the Surgeon's attention; the difficulty depending in a great measure on the various conditions that have just been described not occurring in practice with that amount of distinctness and particularity by which alone their characters can be conveyed in description, but being associated together in such a way that the exact state of the patient cannot so readily be made out. There are few cases, indeed, in which practical tact and a nice discrimination and analysis of symptoms are more required than in those now under consideration. It would, however, be useless to attempt to describe the shades and modifications of treatment required in the management of the different groupings of these various forms of traumatic cerebral disturbance. We must, therefore, content ourselves with describing the treatment of each state broadly and separately, and leave the consideration of the varieties that commonly present themselves in practice to the discretion of the Surgeon.

In the **Treatment of Concussion**, the first great indication is to re-establish the depressed energies of the circulation and of the nervous system. In effecting this, we must be careful not to overstimulate the patient. The safest practice is that which is applicable to the treatment of shock generally —to wrap the patient up warmly in blankets, to put hot bottles around him, or to employ frictions to the surface, and, when he is sufficiently recovered, to allow him to swallow a small quantity of warm tea. Alcoholic stimulants of all kinds should be avoided, unless the depression of the nervous energy be so great that reaction cannot be brought about without their agency; but an enema containing some ether or aromatic spirits of ammonia may be administered.

When reaction has come on, steps should be taken to prevent the occurrence of inflammatory mischief. If the concussion have been slight, it may be quite sufficient to purge the patient well, and to keep him quiet on a regulated diet for a few days, directing him carefully to avoid all alcoholic stimulants and mental exertion for some time. If the concussion have been more severe, and if the symptoms of reaction have been accompanied by indications of continuous cerebral disturbance, or have been followed by giddiness, headache, or confusion of thought, the safer plan will be to adopt immediate steps for the prevention of further mischief. Venesection used formerly to be extensively practised as a precautionary measure, in order to prevent undue reaction and inflammatory mischief following on head-injuries. Perhaps our predecessors erred in the too frequent and liberal use of the lancet in these cases—I believe that Surgeons of the present day are too sparing in its use. In the young and robust the best possible effects follow venesection in head-injuries, to the extent of from 12 to 16 ounces. In children, leeches advantageously take the place of the lancet. The patient should be freely purged, kept on a low diet, and, above all, should remain quiet in bed for some days.

Should impairment of the mental faculties or senses be left, the more prudent plan will be to have recourse to a mild antiphlogistic treatment, con-

sisting of leeching, cupping, blistering, the introduction of a seton in the nape of the neck, purging, and more especially a mild mercurial course, with strict avoidance of all mental and bodily stimulation. The patient must be carefully watched, and kept under proper supervision for some length of time, as serious symptoms are apt suddenly to declare themselves.

When **Acute Inflammation of the Brain or its Membranes** has come on, at whatever period after the injury, active treatment should be at once adopted. The head must be shaved, and cold applied. In the use of cold, great care must be taken that the application is constant. Intermittent cold is worse than useless. One of the best modes of application is the India-rubber ice-cap, which can be secured to the head by a strap passing under the chin; or Leiter's soft metal tubing, which can be moulded to any form, and through which a stream of cold water is kept constantly flowing, is even more efficient. Should these not be available, a bladder filled with ice may be used, but care must be taken that it is firmly secured in its position by bandages, and not, as is too often done, allowed merely to lie against the head, and to be displaced by the slightest movement of the patient. A mackintosh cloth must be placed beneath it to protect the bed-clothes from being wetted. Bleeding from the arm, repeated as often as the pulse rises, as well as by cupping, or leeches, may be had recourse to; the bowels should be freely opened, and rigid abstinence must be enjoined, the patient at the same time being confined to a quiet and darkened room, and removed from all causes of excitement of the special senses. As the disease assumes a chronic form, the same general plan of treatment, modified according to the intensity of the inflammatory affection, must be persevered in, the patient being kept for a length of time after the subsidence of all the symptoms in a state of complete quietude.

The **Subacute Encephalitis** which occasionally follows injuries of the head, even at a remote period from their infliction, is most dangerous and unmanageable, being very apt to terminate in loss or impairment of the senses, in diminution of intellectual power, or in local paralysis. Much of the difficulty in its treatment appears to arise from the fact that the inflammation is often of an asthenic type, and, consequently, does not admit of active depletory measures.

In this disorder the best results are obtained by the proper administration of mercury and the employment of counter-irritants. The best mode of administering the mercury is to give half a grain or a grain of calomel every four or six hours until the gums are affected, and to keep up the effect with diminished doses of the drug. The repeated application of blisters over the shaven scalp is perhaps the most useful form of counter-irritation; to which, in more chronic cases, a seton in the neck may be added. So long as any symptoms of inflammation continue, this plan of treatment must be steadily kept up.

In the more chronic forms of cerebral irritation following injury, more especially if there be any tendency to convulsive movements, bromide of potassium in moderate doses will be found of essential service. It soothes and secures sleep more effectually than any other remedy.

The treatment of **Cerebral Irritation** will require to be varied in different stages of this condition. In the early stage, the treatment that I have found most successful is of a negative character, and consists in the avoidance of all active measures. No good, but much harm, may result from bleeding, purg-

ing, and mercurializing the patient. Complete rest, the removal of all mental and sensual excitement, shaving the head, the application of ice, a mild aperient or an occasional enema, are all that can be done in the way of medical treatment. As the constitutional powers are depressed, they must not be too much lowered by complete abstinence from food, and small quantities of stimulants may usually be advantageously given. A tea-spoonful of brandy in a little water, or beef-tea, every hour or two, according to the condition of the pulse and the temperature of the skin, will generally be required. In some cases, where there is great restlessness, and some delirium, without any sign of encephalitis having supervened, chloral will be found of great value, or an opiate even may be given to quiet the patient and induce sleep. This cerebral irritation is the only form of primary cerebral disturbance in which I have seen opiates act beneficially ; but their administration requires great care, and must not be ventured on if there be any elevation of temperature or quickness of pulse. After a time these signs of depression give way to those of subacute meningitis, the patient becomes noisy, shouting and crying, restless and sleepless. At this period, and in such circumstances, venesection may be practised with great advantage. The bleeding should be followed up by the administration of bromide of potassium or of chloral, and ultimately by the more special treatment of meningeal irritation. In the treatment of all these conditions, it is impossible to insist too strongly on the paramount importance of absolute rest and quietude. No conversation, lights, or noise should be allowed in the patient's room, and no injudicious attempts should be made to rouse him or to ascertain by inquiry if he is conscious. Much depends on careful and quiet nursing ; on attention to minor details, as the avoidance of noises and flickering lights, and the frequent administration of liquid food in small quantities, or per rectum.

In all cases of **Coma from Compression**, the pressure must be relieved before it can be expected that the coma will subside. But, besides this great and obvious indication, which must be carried out in different ways according to the nature of the compressing cause, there are certain general considerations to be attended to, by which the patient's condition may be much relieved. Thus the bowels should be freely opened by placing a drop of croton-oil, mixed with a little mucilage, in the patient's mouth, or by the use of oleaginous or terebinthinate enemata. The urine is to be drawn off twice in the twenty-four hours, the room darkened and kept quiet, and ice or an evaporating lotion applied to the head.

When symptoms of compression occur as the result of *inflammation inside the skull*, the treatment becomes surrounded by difficulties. If, notwithstanding that antiphlogistic measures have been pushed to their full extent, rigors occur and coma supervene, conjoined with a certain amount of continuous inflammatory fever, the question will always arise as to whether trephining should be had recourse to on the supposition of matter having formed. In these cases two great difficulties present themselves ; the first has reference to the existence of pus within the skull, and the second to its situation.

The question as to the actual existence of **Pus within the Skull**, and to the dependence of the symptoms of coma upon the compression exercised by it, is always a difficult one to decide. There are, as has already been stated, no absolute and unequivocal symptoms indicative of the formation of pus within the skull ; symptoms closely simulating those that accompany its

presence being often produced by the effusion of serum, or of puriform lymph, on the brain or its membranes. But although there may not be any symptom that unequivocally indicates the formation of pus in this situation, the Surgeon is not unfrequently enabled, by the assemblage of general symptoms and local signs, to infer its existence with considerable accuracy. In these cases, however, it is usually impossible to determine the exact seat of the pus with sufficient precision to admit of its evacuation by the trephine—whether it be between the skull and the dura mater, between the layers of the arachnoid, underneath this membrane, between the cerebral convolutions, or deeply seated in the substance of the brain; whether it be situated under the seat of injury and be there circumscribed, or so extensively diffused as not to be capable of complete evacuation. The side that is either wholly or chiefly the seat of the suppuration is necessarily determined by the existence of opposite hemiplegia; but the precise localization of the pus in the intra-cranial structures of the side affected constitutes the point of diagnostic difficulty. As a general rule, it may be said that when the signs of suppuration supervene early after the receipt of a head injury, the pus is diffused and its seat is in the membranes. When the symptoms are slow in onset, being those of compression rather than of inflammation, it is circumscribed and in the brain substance. That these difficulties are real must be obvious to every practical Surgeon; and in illustration I may mention the following two cases, out of many that I have witnessed.

A man was admitted into University College Hospital with an extensive lacerated wound of the scalp, denuding the pericranium. He continued free from all cerebral disturbance until the tenth day after the accident, when he complained of headache, and had a quick pulse and a hot skin; at this time it was observed that the pericranium had separated from the skull. Active antiphlogistic treatment was followed by subsidence of symptoms, and the patient went on favourably until the thirty-fourth day, when he suddenly became delirious and then unconscious, though easily roused when spoken to loudly, and then answering rationally; his pulse fell to 48. He died on the thirty-ninth day, comatose. On examination after death, the pericranium was found detached at the seat of injury; under this the dura mater was thick, yellow, and opaque, but no pus was observable. On separating the hemispheres, however, a large abscess was found situated deeply in the anterior lobe on the injured side, and protruding into the median fissure. It contained about one ounce of pus. In such a case as this trephining would evidently have been useless; for, although it was probable that there was pus within the skull, yet its seat could not have been diagnosed, and the abscess could never have been reached.

Another case admitted into the Hospital was that of a man who had received a large lacerated wound on the left side of the scalp in consequence of a fall. There was no injury to the bone, and the patient went on perfectly well until the seventy-seventh day, the wound having cicatrized. He was then suddenly seized with hemiplegia of the right side, from which he recovered partially on being bled; some twitching of the muscles, however, continued. On the ninety-ninth day after the accident he became comatose, and was trephined by S. Cooper, but without relief, dying with symptoms of compression of the brain on the third day after the operation. On examination thick yellow lymph was found, covering the whole of the upper surface

of both hemispheres, lying between the arachnoid and pia mater, and extending into the sulci between the convolutions. There was an abscess in the substance of the brain near the surface of the right hemisphere—the side opposite to the seat of injury. Here also, though the symptoms were well marked, and the diagnosis as to the existence of pus correct, trephining was useless, as the pus could not be evacuated. These cases serve to indicate the difficulties that surround any operation with the view of evacuating matter from within the cranium.

When, however, the symptoms of inflammation have been interrupted by an attack of rigors followed by coma, or accompanied by paralysis on the side opposite to the seat of injury, with the formation of a puffy swelling of the scalp, or by the separation of the pericranium and the exposure of yellow and dry bone at the bottom of the wound, there can be little doubt that the Surgeon, though bearing in mind the extreme uncertainty of the case, might be justified in trephining at the seat of local change or of injury, in the hope of finding and evacuating pus lying beneath the skull, and thus giving the patient his only chance of life. And indeed, if the *local* changes just described be well marked, the bone being dry, having lost its vitality, and not bleeding from the diploë when cut, the probability of finding pus immediately beneath the trephine aperture, and seeing it well up by the side of the instrument as the bone is perforated, is very great. And should it not be met with there, and the dura mater appear bulging, and without pulsation, an incision might even be made through this membrane, in the hope that, the abscess being circumscribed, the escape of the pus might be facilitated. If pus is reached here it will spirt out with much force.

The absence of the ordinary pulsatory movement of the brain is an important diagnostic sign in these cases, indicating the presence of pus either under the dura mater or in the substance of the brain; but if the abscess be of moderate size and situated in the cerebral substance the pulsations may persist and even be well marked, as in Hulke's case of successful trephining for cerebral abscess. Should the incision through the dura mater fail to reach the pus, few Surgeons would have the hardihood to follow the example of Dupuytren, who plunged a bistoury into the substance of the brain and thus luckily relieved the patient of an abscess in this situation. A careful search may, however, be made for the pus by means of a grooved needle or an aspirator. If the latter instrument be used only a partial vacuum should be produced, otherwise the soft cerebral substance will be forced into the needle and choke it. Hulke in this way detected the presence of an abscess in the frontal lobe of the brain in a boy aged 15, seven weeks after he had received a blow on the forehead causing a small stellate fracture of the outer table of the skull which was not discovered at the time of the accident. The abscess, which was situated about one inch below the surface of the brain, was opened by a knife passed along the aspirator needle, and about ʒiij of thin greenish pus were evacuated. The boy recovered, but unfortunately became completely blind from atrophy of both optic papillæ following on neuro-retinitis. Hulke was led to infer the presence of an abscess in this case chiefly by the fact of hemiplegia supervening gradually many weeks after an injury to the head, a symptom to which he attaches much importance. In such cases a careful exploration by means of a fine needle cannot possibly increase the danger of the patient and may be the means of saving his life. Care must be taken,

however, that the needle is pushed straight onwards in the direction intended, all lateral movements being carefully avoided, and in this way several punctures in different parts may safely be made. When the paralysis is limited, as to one limb or to the face and arm, the modern discoveries as to the localization of the functions of the brain may serve as an indication to the situation of the abscess. In this way Macewen was able to recognize the position of a cerebral abscess, and the diagnosis was confirmed by post-mortem trephining, the friends of the patient having refused to permit the operation during life.

In spite of the few isolated cases of recovery such cases must necessarily be almost hopeless. Though pus be actually found under the skull, between it and the dura mater, and be evacuated, I fear that the patient's chances of recovery will not be very materially increased, as the encephalitis will continue, and eventually lead to his death. In my own experience, I have never met with a case of recovery under these circumstances ; and P. Hewett states that the successful termination of a case of trephining for pus within the skull, even between it and the dura mater, is all but unknown. Yet, in the face of this unfavourable prospect, it appears to me that trephining is the proper course to pursue. As the pus cannot evacuate itself, it is perfectly certain that death must ensue if it be not let out. As the only chance of life, therefore, is in the use of the trephine, it appears to me to be proper to have recourse to this, however doubtful may be the result.

The **Treatment of Pyæmia** from injury of the skull must be conducted on those ordinary medical principles that guide us in the management of pyæmia, from whatever cause arising.

Summary of Treatment.—The following treatment should be applied in all cases of head-injury attended by unconsciousness, whether special operative interference be needed or not :—

1. The head must be shaved and elevated on hard pillows.
2. Any scalp-wound treated antiseptically.
3. The icebag applied to the head—hot bottles to the feet.
4. From two to five grains of calomel placed on the tongue.
5. The lower bowel emptied by a turpentine enema on the second or third day.
6. The room darkened—the necessary fire and lights being screened.
7. No conversation in the room allowed—all noises avoided—slippers substituted for creaking boots—the coal put on with the hand—the fire stirred with a stick.
8. The diet to consist of spoon-food—iced milk or at most chicken-broth, thickened with arrowroot or cornflour.
9. If the patient cannot swallow, nutritive enemata may be given every fourth hour.

INJURIES OF THE SCALP.

Contusions of the Scalp from blows are of common occurrence, and present some peculiarities. However severe the contusion may be, it seldom happens that the scalp sloughs. This is evidently owing to the great vascularity and consequent active vitality of the integuments of the head. In many cases, a contusion in this situation is followed by considerable extravasation of blood, raising up the scalp into a soft semi-fluctuating tumour. It occasionally happens, especially in blows on the heads of children, that this

extravasation gives rise to the supposition that fracture exists, owing to the edge of the contusion feeling hard, whilst the centre is soft, causing an apparent depression of the subjacent bone. In some cases, indeed, this deceptive feeling will occur without any considerable extravasation of blood under the scalp, the depressed centre being due to the compression of the scalp by the blow that has been inflicted upon it. This I have seen occasionally in children in whom the scalp is soft and somewhat spongy. The difficulty of distinguishing between such an extravasation and a piece of depressed bone is often so great as to mislead the most experienced Surgeons. Usually it can be effected by feeling the smooth bone at the bottom of the soft central depression, and by an absence of symptoms of compression. If seen soon after the accident the raised edge can usually be made to melt away under the finger by firm pressure, till the solid bone can be clearly felt beneath, at the same level as that in the centre of the swelling. But in the event of doubt, if symptoms of compression of the brain are present, it will be safer to make an incision, and so to examine directly the state of the bone itself.

The **Treatment** of contusion of the scalp is very simple ; the continuous application of evaporating lotions being usually sufficient for the removal of all effusion. In no circumstances should a puncture be made or the blood let out in any way. Contusions of the scalp in girls and young women have been followed by severe neuralgic pains in the part struck. This affection is extremely rebellious to treatment ; but in two cases which I have seen, after lasting for a long time, these symptoms gradually disappeared. In such cases, incisions down to the bone are said to have sometimes been beneficial.

CEPHALHÆMATOMA.—It occasionally happens that bloody tumours of the scalp form in newly-born children, either from contusion of the head in consequence of the pressure to which it is subjected in its passage ; or from the bruising of obstetric instruments. These tumours, which are often large and fluctuating, are termed **cephalhæmatomata.** They may occur in two situations, either *between the aponeurotic structures of the scalp and the pericranium*, or *between this membrane and the skull itself.*

The **Subaponeurotic Cephalhæmatoma** is by far the most common variety. It usually forms a large, soft, fluctuating tumour, situated upon one of the parietal eminences, and having a somewhat indurated circumference. The tumour will usually subside in a few days under the use of discutient lotions.

The **Subpericranial Cephalhæmatoma** is an injury of somewhat rare occurrence ; it has been described by Zeller, Valleix, and others. It appears as a fluctuating tumour, almost invariably seated on one parietal bone, without discolouration of the scalp, but with a hard elevated circle around it, and a soft depressed centre, almost communicating the sensation of a hole in the cranium. Pressure, however, gives rise to no cerebral symptoms, and enables the Surgeon to feel the bone at the bottom of the depression. These tumours are usually small, seldom more than two inches in diameter, and it occasionally happens that they are multiple. It is worthy of note, however, that each tumour is always confined to a separate bone, never passing beyond the sutures, where the adhesions are the strongest between the pericranium and the subjacent osseous structure. This affection is said to be most frequently met with in children born in first confinements, and is more common in boys than in girls ; according to Bouchard, in the proportion of thirty-four to nine.

The **Pathology** of this affection has been studied by Valleix, who found that the pericranium was separated from the bone by an extravasation of blood, and that both bone and pericranium were covered with decolourized clot, but otherwise healthy; the fluid in the centre was the serum from the coagulated blood. He found also that the hard circle surrounding the depression was formed by a deposit of osseous tissue in the angle formed by the raised periosteum and the bone beneath. This deposit was effected in such a way that, on a transverse section being made, the inner wall was found nearly perpendicular, whilst the outer sloped down upon the cranium, thus giving a crateriform appearance to the margin of the tumour.

The *Treatment* must be conducted upon precisely the same principles as that of the other forms of extravasation. If seen early, the fluid is best removed by means of an aspirator. Occasionally it fills again after this, and the operation must then be repeated. The same treatment may be followed with advantage even after the bony rim has formed round the swelling.

Wounds of the Scalp are of very common occurrence, and are more serious than corresponding injuries elsewhere, especially in persons about the middle period of life, and of unhealthy or broken constitution. Not only are these injuries said to be more likely to be followed by erysipelas than those of other parts of the body, but the great tendency to the propagation of inflammatory mischief inwards to the encephalon, and to the complication of cerebral mischief, often accompanying comparatively slight injuries of the scalp, gives to these accidents much of their serious and often fatal character. But, though there be this danger to life in scalp-injuries, there is comparatively little risk to the scalp itself; its supply of blood is so abundant, and its vitality consequently so great, that sloughing seldom occurs, even though the part be much bruised and seriously lacerated.

The **Treatment** of wound of the scalp necessarily varies somewhat according to the nature of the injury. If this be a simple cut, it will be sufficient, after shaving the parts around and cleansing the wound, to bring it together with a strip or two of adhesive plaster, and to dress it as lightly as possible. If the incision in the scalp be extensive, the lips of the wound must be brought together by a few points of metallic suture, or by hare-lip pins. If there be arterial hæmorrhage, this may usually be best arrested by the pressure of a pad and bandage, the firm bone beneath providing excellent counter-pressure. Should this not be convenient, the bleeding vessels may usually be secured without difficulty by ligature or torsion, although occasionally some trouble may be caused by the density of the tissues in which the vessels are lying. Should other means fail, a pin may be passed beneath the artery, and compression made over it by a figure-of-8 suture. In this, as in all other cases of injury of the head, especial attention should be paid to the state of the brain; for, however slight the external wound may be, serious cerebral mischief may have been occasioned.

It more frequently happens that the scalp is bruised and lacerated as well as wounded; and very commonly that a large flap of integument is stripped off the skull, and is thrown down over the face or ear, so as to denude the bones. In these cases, advantage is taken of the great vitality of the scalp. However extensively contused or lacerated this may be, however much it may be begrimed with dirt, it is a golden rule in surgery not to cut any portion of it away, but,

after shaving the head and ligaturing any bleeding vessels, to wash and clean it thoroughly, and replace it in its proper position. Here it must be retained by the support of a few strips of plaster, or by the application of a suture or two at the points of greatest traction: for this purpose, thick silver-wire is better than silk or thread. The use of sutures has been deprecated by many Surgeons in injuries of the scalp, as tending to favour erysipelas; undoubtedly, much mischief will arise if an attempt be made to stitch up the wound closely, and in small wounds sutures are generally unnecessary. But in extensive lacerations, more particularly of the anterior part of the scalp, where the soft parts are stripped off, and hang over the occiput as the patient lies down, they cannot be dispensed with; and here I have never seen any but the best consequences follow their use at those points where the torn surfaces can be readily approximated. In cases of this kind, the under surface of the scalp granulates, and union by the second intention takes place between it and the pericranium. In the majority of cases, dry dressings will be found most efficient. Pads of iodoform-wool, salicylic wool or silk, or some other dry absorbent antiseptic preparation, may be applied, and secured with a bandage, so as to exert a gentle elastic pressure and to retain the separated parts in apposition and at perfect rest, while at the same time the accumulation of discharges is prevented. Such a dressing may frequently be left untouched for a week or ten days, at the end of which time union will be perfect. The indications for removing it earlier are an offensive smell of putrefaction, a rise of temperature, pain, or a puffy swelling of the scalp beyond the dressing. The patient should be freely purged, and kept perfectly at rest on a rather low diet; any cerebral symptoms that occur being treated in accordance with the principles laid down in discussing traumatic affections of the brain. In this way, union will very probably take place through the greater portion of the injured surface; should it not do so, however, or should any part slough, granulations spring up, and repair goes on with surprising rapidity. If pus form beneath the aponeurosis of the occipito-frontalis muscle, bagging must be prevented by early counter-openings, and by the employment of compression in proper directions.

It is important to make the diagnosis between erysipelas of and diffuse suppuration under the scalp. This may, as a rule, be done by observing that in erysipelas the red tumefaction of the scalp extends from the margins of the wound, and early stretches beyond the true limits of the pericranium, invading the eyelids, attacking the ears, and extending to the face and neck; whilst in suppuration beneath the pericranial aponeurosis the mischief is limited by the attachment of that membrane. The pericranial aponeurosis or tendon of the occipito-frontalis muscle is firmly attached to the fat and fascia superficial to it, whilst it is connected in the loosest manner possible with the parts underneath. This arrangement is often of great service in protecting the skull from fracture, especially when the head is caught between two solid bodies, as, for example, the wheel of a cart and the ground; the scalp is then torn off and the head slips away, thus escaping further injury. In suppuration occurring under the tendon of the occipito-frontalis, the pus gravitates to the most dependent parts until arrested by the attachments of the aponeurosis. These attachments are as follow. Posteriorly, the fleshy bellies and tendon are attached to the superior curved line of the occipital bone, and to mastoid process along line of insertion of sterno-mastoid.

Laterally, the tendon is thin, covered in part by the attollens and attrahens aurem, and in front of the ear runs down, superficial to temporal fascia, to be attached, like it, to the zygoma ; pus gravitating in this direction, therefore, forms a bag of fluid just above the zygoma, never extending into the cheek. In front, the fleshy fibres of the muscle are blended with those of the corrugator supercilii and the orbicularis palpebrarum ; while in the middle line they are continued down over the nose into those of the pyramidalis nasi ; and the pus under this part will therefore collect in the upper eyelids, and in a pouch over the root of the nose.

When the wound is too tightly closed, either by sutures or by a pad of lint allowed to stick to it by the dried blood, the serous fluid, necessarily effused in the first few hours, forces its way into the loose areolar tissue beneath the pericranial aponeurosis. If the wound be small it may possibly occur that the fluid is absorbed, and the wound heals without trouble. Frequently, however, it distends the lymph-spaces and decomposes, and thus starts a spreading inflammation which may affect the whole of the subaponeurotic areolar tissue. This septic cellulitis commences usually about the third day after the injury, and terminates, as such inflammations generally do, in diffuse suppuration and sloughing of the cellular tissue. There is a general puffy swelling of the scalp and diffused redness, often extending over the face, and it is probable that this state of things has often been confounded with erysipelas, and has given rise to the idea that stitches in the scalp cause that disease. This condition is frequently fatal, especially in old people, unless actively and efficiently treated; death occurring either from septic poisoning, pyæmia, or exhaustion. As soon as pain, with some swelling round the wound and elevation of temperature, raise a suspicion that diffuse inflammation is spreading from the wound, all dressings should be removed. It will frequently be found that edges of the wound are adhering to each other ; if this be the case they must be separated with a director, when a small quantity of thin offensive pus frequently escapes. A hot dressing of boracic-acid-lint may then be applied, and covered over with oil-silk, and over this a sheet of cotton-wool and a bandage. This must be changed, like a poultice, about every four hours. In most cases this treatment will be successful in arresting the unhealthy inflammation, but should it fail and the cellulitis extend more widely, it will be necessary to make free incisions, reaching through the pericranial aponeurosis wherever the inflammation has extended. Before doing this the head must be shaved ; without this cleanliness is impossible. It is more essential that this should be done with women even than with men, however much they may object, as their hair is longer. The incisions should be each about one inch in length, and vary in number according to the extent of the mischief. They must be carefully planned so as to avoid the main arteries. After bleeding has been arrested hot dressings must be applied as before described.

Simple erysipelas after a scalp wound presents nothing special in its treatment.

When the skull itself is extensively denuded in consequence of the pericranium being stripped off the subjacent bone together with a flap of the scalp, it does not necessarily follow that necrosis and exfoliation of the exposed bone will occur. The flap must be laid down on the denuded osseous surface, to which it may possibly contract adhesion through the medium of granulations.

Should it, however, slough, and a large portion of the skull be exposed, exfoliation of the outer table, though probable, does not necessarily happen; for, in some cases, granulations will spring up on the exposed portion of the skull, and a covering be formed to the bone.

FRACTURES OF THE SKULL.

Injuries of the Bones of the Skull, especially Fracture, possess great interest, not so much from the lesion of the bone itself, as from its frequent complication with injury of the brain and its membranes. This cerebral complication may either be produced by direct injury, the fragments of the fractured bone compressing or wounding the brain; or it may be the result of concussion or laceration of the brain by the same violence that causes the fracture.

Bending-in of the Cranial Bones without Fracture is an accident that may occur in infants and young children, before the bones of the skull are completely ossified. In several instances, the displaced bone has been raised by aspiration with an india-rubber sucker. But no harm comes of leaving the bone depressed, as it will generally recover its proper level in time.

Contusion of the Cranial Bones without fracture, occasioned either by ordinary direct violence or by the oblique impact of bullets, is a very serious injury, more particularly when complicated with wound of the scalp. In it there are four sources of danger, any one of which may be followed by a fatal result; viz.: 1. Necrosis of the part of bone struck, leading to exfoliation of the outer table, or to separation of the whole thickness of the cranium and exposure of the dura mater; 2. Suppuration under the bone, between it and the dura mater; 3. Pyæmia with secondary visceral abscesses, consequent on suppuration of the diploë around the necrosed point of bone, and the entrance of pus into the cranial veins—a condition to which reference has already been made; and, 4. Laceration of the brain immediately beneath the point struck, or at the corresponding spot on the opposite side of the brain. The former condition occurs only when the blow is very violent, sudden, and limited to a small area, as when the skull is grazed by a bullet. Under other circumstances the chief laceration is always on the opposite side of the brain.

The following statement, taken from the records of the War-Department of the United States army, gives a good summary of the results of gun-shot contusions of the skull without fracture, or, at any rate, in which the fracture was limited to the inner table. In many of these there was without doubt some superficial laceration or bruising of the brain.

Of 328 cases, there died 55; were disabled, 173; recovered, 100. The deaths arose from hæmorrhage, 2; tetanus, 4; pyæmia, 4; dysentery and fever 8; compression from blood or pus, 17; various intracranial injuries, 20.

In 221 cases the seat of injury is mentioned with the percentage of mortality as follows:—

	Cases.	Deaths per cent.
Frontal bone	54	15
Temporal „	33	15
Parietal „	95	13
Occipital „	33	9
More than one bone	6	0

This shows these injuries to be most dangerous in the temporal and frontal regions, and least so in the occipital.

Amongst the 173 disabled, the following complications are specified as the causes of the disability :—

10 Persistent pain in the head. Vertigo, giddiness, and dizziness were some of the commonest complaints among pensioners.
23 Paralysis of limbs more or less marked.
16 Impairment of vision ; wound mostly in frontal region.
14 Impairment of hearing ; wounds mostly in parietal and temporal regions, but some frontal and some occipital.
9 Epilepsy.
10 Insanity.

Fractures of the Skull are invariably the result of external violence. This may act *directly* in breaking and splintering the part struck, the fissures often extending to a considerable distance and detaching large portions of the skull ; or the violence may act in an *indirect* manner, producing the fracture either without being applied immediately to the cranium, or else at an opposite part of the skull to that which is struck. Thus the base of the skull may be fractured by the shock communicated to it when a person, falling from a height, strikes the ground heavily with his feet. A variety of indirect fracture in which the lesion occurs at a point of the skull opposite to that which has been struck has received the name of Fracture by Contrecoup.

Fracture by Contrecoup has been described by some Surgeons as of frequent occurrence, whilst it has been denied by others. Aran laid down as an absolute rule that all fissured fractures without exception start from the point in the skull to which the violence has been applied. Every hospital Surgeon must, however, occasionally have met with fissures, especially in the thin parts of the base of the skull, which could not be traced to the point in the vault which directly received the injury, but such cases are undoubtedly very rare. Moreover, it must not be concluded at once that such fissures are the result of *contrecoup*. A man may receive a violent blow on the frontal bone, wounding the scalp, and the fracture may be found in the occipital region. In such a case, it often happens that the fissure was really caused by a blow on the back of the head received in falling. In other cases in which the patient falls directly on the vertex and fractures the base of the skull, the fracture is often caused by the weight of the body communicated through the vertebral column to the condyles of the occipital bone. It has been shown experimentally by C. Bell, Bruns, and Félizet, that the skull possesses a considerable degree of elasticity, and that when a violent force such as a blow acting on a considerable extent of the surface, or powerful pressure is applied to it, it undergoes an alteration in shape not merely at the point struck, but as a whole. There is a shortening of the diameter corresponding to the direction of the force, with lengthening of the other diameters. Thus, a force applied to the vertex tends to shorten the vertical diameter, and to cause a corresponding lengthening of the antero-posterior and transverse diameters. A skull thus squeezed out of shape may yield at the weakest part, and a fissure may thus be formed at a point remote from that to which the force was applied, although much more commonly the blow determines the starting point of the fissure. That the fissures in a fractured skull may actually gape at the moment and close again as soon as the force ceases to act, is occa-

sionally proved by the presence of foreign bodies tightly grasped in them. Thus, hairs have been found firmly held in the crack, and Hoffmann records a case in which a fold of dura mater was nipped in a fissured fracture. The rending force thus exerted by the compression of the skull in one direction and its elongation in another explains perhaps more readily than any other theory the distance to which a fissure often extends, and the way in which it often follows for a certain distance along the line of a suture, entering the solid bone again when the suture comes to an end, and also the fact that a foramen, even the foramen magnum, offers no impediment to the extension of the fracture.

In certain cases the thin orbital plates of the frontal bone have been found to be fissured after violent blows on the back of the head, and in these it has been suggested that the fractures resulted from the impact of the brain substance driven against the bone by the force of the blow.

If all these different forms of fracture be excluded, but little is left that needs the theory of *contrecoup* for its explanation.

Although, therefore, Aran's rule, that all fissures radiate from the point struck, is not absolutely accurate, yet it is so nearly so that it forms the best guide we have to the course of a fracture. Thus, if we have clear evidence that a man has received a blow on the parietal eminence, and he has profuse bleeding from the nose, we may reasonably conclude that the fracture roughly corresponds to a line drawn from the point struck to the cribriform plate. In a case under my care in University College Hospital the patient had received a violent blow, not causing a wound, on the right occipital region, and was bleeding freely from the left ear. Soon after admission the respiration became greatly embarrassed without any signs of general compression of the brain. Following Aran's rule, the diagnosis made was, that a fissured fracture crossed the foramen magnum, and that extravasated blood was pressing on the medulla oblongata; a conclusion which was confirmed by the post-mortem examination.

Fissured Fracture.—An ordinary **undepressed fracture** of the skull consists in a fissure, sometimes single, at other times starred, extending often to a considerable distance through the bones, radiating sometimes across the skull, and in other cases completely detaching its upper from its lower part, or its anterior from its posterior segment. In some cases the fracture extends into one of the sutures; and in other instances, which, however, are very rare, the sutures are separated without any fracture.

A fissured fracture usually results from direct violence, but is also the only form of fracture that can possibly arise by *contrecoup*. A fissure gives rise to no signs by which its diagnosis can be effected, and often escapes detection altogether, more particularly when the scalp covering it is not wounded, or, if contused, when so large a quantity of blood is extravasated as to render it impossible for the Surgeon to feel the subjacent bone. If, however, the scalp covering the injured bone have been wounded, the existence of a fracture may be ascertained by running the finger-nail, or the end of a probe, over the exposed surface of the bone, or by seeing a fissure which remains filled with blood after wiping the surface, or from which blood may be freely oozing.

As the whole importance and danger of fracture of the skull depend, not upon the injury that the bone has sustained, but on the concomitant or secondary lesions of which the contents of the cranium may be the seat, no special

Treatment is required for the fracture itself when simple and undepressed, the Surgeon's whole attention being directed to the injury that may have been inflicted on the brain or scalp. Should the fracture be compound the wound should be carefully cleansed with carbolic lotion (1 in 20), and some antiseptic dressing applied. The patient's safety depends to a great extent upon the prevention of decomposition. In all fissured fractures there is necessarily some blood extravasated between the dura mater and the bone, as well as in the diploë, supposing the fracture to be in a part where this exists. If this extravasated blood should decompose, the patient would run all the dangers of suppuration between the dura mater and bone or septic inflammation of the diploë. Moreover, it is always possible that the dura mater may be torn even beneath a simple fissure, though fortunately this is rare. Should this however have taken place, and decomposition of the discharges occur, the danger of septic meningitis setting in is very great; and should this happen, the death of the patient is a certain consequence. After the wound has been cleaned it may be dressed with Lister's gauze or with iodoform or salicylic wool secured by a bandage. Should this not be available, lint dipped in carbolic oil (1 in 10) or in equal parts of glycerine of carbolic acid, and water, forms an excellent dressing.

Although the most important precautionary measures for guarding against inflammation of the brain and its membranes are doubtless those intended to prevent septic processes in the wound, yet other measures should on no account be neglected. The head should be shaved if this has not already been done in dressing the wound, and cold may be applied. This can easily be done over Lister's dressing or over the carbolic oil, but it can hardly be efficiently employed over iodoform or salicylic wool; and this, perhaps, in some cases forms an objection to their use. Care must be taken in all cases not to soak the dressing with water oozing through a half-putrid bladder; the india-rubber ice-cap should be used when possible, or if that be not at hand a common sponge-bag will answer the purpose fairly well. The bowels should be well opened, and the room kept cool and quiet. Should any symptoms of inflammation of the brain make their appearance, free, and if need be, repeated bleeding is, perhaps, of more service than any other means, and should never be omitted, except in feeble, very young, or aged subjects.

In **Chronic Hydrocephalus**, the cranial bones are thinned and expanded; but, being at the same time preternaturally elastic and mobile, they are seldom fractured. When they are so injured, the presence of the water may save the brain from the direct effects of the blow. In one case that was under my care, the hydrocephalic child fell from the top of a house on to its head, and sustained a long fracture through the left side of the skull, but without any scalp wound. Shortly after the accident, a large soft fluctuating tumour formed under the scalp opposite the line of fracture; and, on this being tapped, about three ounces of cerebro-spinal fluid were drawn off. This operation was repeated, but the child died about ten days after the injury, with hemiplegia of the opposite side, and with convulsions.

Fracture of the Base of the Skull.—The most serious, and indeed a very commonly fatal form of fissure or simple fracture of the skull, is that which extends through its *base*. It may occur in three ways. 1. This injury is usually caused by direct violence, as by a fall or a blow upon the vertex or side of the head, producing a fracture which extends from the point struck

across to the base of the skull, after running through the petrous portion of the temporal bone or into the foramen magnum. 2. It may also possibly take place as the result of *contrecoup*, the blow being received on the forehead, back, or side of the head, and the jar of the bones expending its greatest violence on and fracturing the base of the skull; and 3, by the impact of the spine against the condyles of the occipital bone causing a fracture that radiates from the foramen magnum. This kind of fracture of the bone is well illustrated by the annexed cuts (Figs. 310, 311), taken from patients of mine who fell from a height on the head. The effects will vary according to the character of the

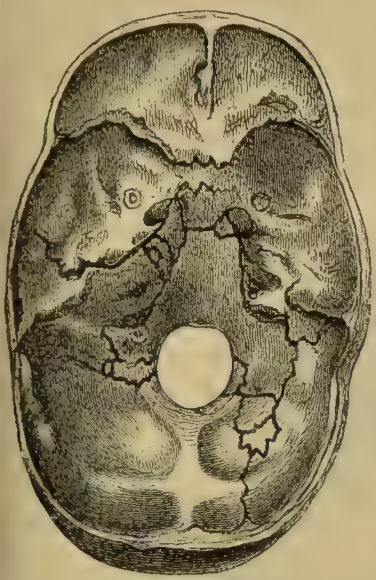


Fig. 310.—Splintering of edges of the Foramen Magnum and Radiating Fracture of Base of Skull from Fall on Vertex.

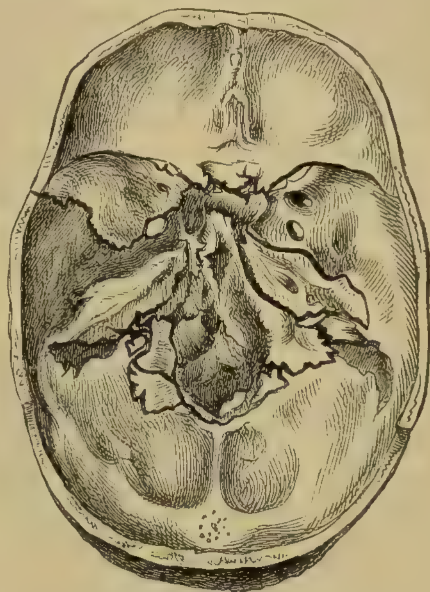


Fig. 311.—Fracture of Base by Fall on Vertex. Both Condyles broken off and driven in. Vertex was fissured.

surface on which the person falls. If it be hard, as stone, the vertex will be smashed in, and if there be fracture of the base, it will be occasioned in the first way. If the head strike soft ground, the body will be violently projected against the base of the skull, and this variety of fracture may be occasioned by the force of the impact; and it has occurred as the consequence of alighting on the feet from a great height, when the shock has fissured the occipital bone from the edge of the foramen magnum outwards. One great danger in these cases arises from the concomitant injury to the brain, either by direct laceration or by the extravasation of blood on its under surface. The important nervous centres that lie directly upon the parts of the skull that are broken are specially liable to injury, and free hæmorrhage often takes place from a torn sinus or a ruptured cerebral artery. Another danger of equal importance is septic meningitis, which kills a considerable number of these cases. Its occurrence is explained by the fact that a very large proportion of all fractures of the base of the skull are compound. All cases which implicate the tympanum with rupture of the membrana tympani, all those which fracture the basilar process and tear the mucous membrane at the upper part of the pharynx, and all those implicating the sphenoidal sinus and the cribriform plate of the ethmoid are compound fractures, and are exposed to all the accidents to which those injuries are liable. A good example of the way in which such injuries may

prove fatal occurred in a case under my care in University College Hospital in 1872. The patient was a woman, aged twenty-seven, who fell from a first-floor window into the street below. She received a violent blow on the face, fracturing the upper and lower jaws, the zygomatic arches, and the nasal bones. She soon recovered consciousness, and showed no signs of serious cerebral injury. However, on the second day symptoms of meningitis set in, and on the third day she died comatose. The *post-mortem* examination showed the usual signs of septic meningitis, and the source of the mischief was found to be a small puncture of the dura mater made by a triangular fragment of the thin bony roof of the sphenoidal sinus which had become displaced vertically, opening up the sinus below by tearing the mucous membrane. The fragment was isolated by the branches of a fissured fracture which extended backwards from the frontal bone, but at no other part was the dura mater injured. The brain showed superficial bruises in the frontal lobes.

Fractures of the Base, though usually fatal, are not invariably so. Not only does it occasionally happen that patients with all those signs of fracture of the

Fig. 312.—Fracture of Base of Skull implicating the Tympanum.

base of the skull, which will immediately be described, are seen to make a complete recovery, but in the different Museums specimens illustrative of recovery after this accident may be met with. Thus, in the College of Surgeons' Museum, there is the skull of a person who lived two years after a fracture of this kind.

Signs.—Fracture of the base of the skull is very commonly suspected when symptoms indicative of serious injury to the brain speedily follow a severe blow upon the head. Those parts of the nervous centres that are most important to life are more liable to injury in this than in other fractures of the skull; the same violence that occasions the fracture injuring the contiguous portions of brain, or lacerating some of the large venous sinuses at the base of the skull, and thus giving rise to abundant intracranial extravasation of blood.

The patient whose skull is represented in Fig. 312 died from injury to the medulla oblongata and hæmorrhage into its substance; a result which can hardly be wondered at, when the splintered condition of the margin of the foramen magnum is taken into consideration. There was no other serious injury to the brain. After a short period of unconsciousness, the patient became noisy and talkative, and was somewhat troublesome on his way to hospital, but almost immediately after admission, his respiration and pulse began to fail, and he died in half an hour or less from the time of the accident.

The symptoms of Fracture of the Base are in the highest degree equivocal;

and much anxiety has consequently been manifested by Surgeons to discover some special sign of the occurrence of this particular fracture.

The signs of fracture of the base of the skull will necessarily vary according to the seat of injury. When the fissure extends through the *anterior fossa*, there may be extravasation of blood into the orbit or eyelid, or free hæmorrhage from the nose. When it implicates the *middle fossa*, there is, very frequently, fracture of the petrous portion of the temporal bone, with rupture of the tympanic membrane, and then there will be bleeding or a watery discharge from the ears. When the *posterior fossa* is the seat of injury, the signs are more equivocal, unless the fissure extend forwards to the petrous portion of the temporal bone, when the more characteristic signs will occur. In some cases, discoloration of the skin from extravasated blood behind the mastoid process and at the back of the neck, when there has been no direct injury in that situation, may indicate the presence of a fracture.

There are two signs, the occurrence of which, separately or together, leads to strong presumptive evidence of the existence of this kind of fracture. 1. The Escape of Blood from the interior of the Cranium through the ears, nose, or into the orbit; and 2. The Discharge of a Serous Fluid from the Ears, and occasionally from other parts in connection with the base of the skull.

1. The occurrence of **Bleeding from one or both Ears** after an injury of the head cannot by itself be considered a sign of much importance, as it may arise from any violence by which the membrana tympani is ruptured, or the cartilage of the pinna separated from the bone, without the skull being necessarily fractured. If, however, the hæmorrhage be considerable, trickling slowly out of the external auditory meatus in a continuous stream, if the blood with which the external ear is filled pulsate, and more especially if the bleeding last for three or four hours and be associated with other symptoms indicative of serious mischief within the head, and if it have been occasioned by a degree of violence sufficient to fracture the skull, we may look upon the hæmorrhage as strong evidence that a fracture of the base, extending into the petrous portion of the temporal bone, has taken place, and that, perhaps, one of the venous sinuses in its neighbourhood is torn. The evidence, however, is only presumptive; it is not positive as to fracture of the base of the skull through its petrous portion, nor indeed of any intracranial injury whatever. Copious hæmorrhage from the ear to the extent of many ounces has been known to occur from a fracture of the anterior and inferior part of the meatus auditorius externus, in consequence of the condyle of the lower jaw being forcibly driven up against it, the jaw itself having been fractured.

Hæmorrhage into the Areolar Tissue of the Orbit and Eyelid, giving rise to extensive ecchymosis of the lid, possibly with protrusion of the eye-ball itself, often accompanies fracture of the orbital plate of the frontal bone. The ecchymosis that occurs in these cases arises from the filtration of blood from the interior of the skull, through the fracture, into the loose areolar tissue adjacent to the injured bone. It differs remarkably in appearance from that resulting from a direct blow upon the eyelid—from a "black eye." In the latter case there is bruising of the skin, and the ecchymosis is in a great measure cutaneous, of a reddish-purple colour. In the ecchymosis from fracture, the hæmorrhage is entirely subcutaneous and subconjunctival; there is probably no bruising of the eyelid, but this is tense, greatly swollen, and of a bluish-purple colour. The extravasation appears under the ocular

conjunctiva in a very marked manner, which is rarely the case in an ordinary black eye, where the ecchymosis is superficial to the palpebral ligament, and shut off by it from the subconjunctival areolar tissue. In the more severe cases, in which there is distinct protrusion of the eyeball, the hæmorrhage may be venous or arterial. When venous, it probably arises from a fracture, implicating the body of the sphenoid bone, and tearing the wall of the cavernous sinus. When arterial, it may, as Hewett has shown, be the forerunner of a circumscribed traumatic aneurism of the orbit, attended by pulsation, bruit, and projection of the eyeball, requiring the deligation of the common carotid for its cure.

Bleeding from the Nose or Mouth may of course arise from any injury of these parts without the skull being implicated; yet in some cases of fracture of the skull the hæmorrhage proceeds from the interior of the cranium, through a fissure in the roof of the nasal fossa; it then indicates a fracture through the ethmoid and sphenoid bones. In a patient of mine who died five weeks after an injury of the head, accompanied by bleeding from the nose, a fracture occasioned by *contrecoup* was found extending across one orbital plate of the frontal bone, and separating its articulation with the ethmoid. In this case, the nature of the injury was suspected from the fact of the nose itself having been uninjured by the blow, although the hæmorrhage from it was very considerable and continuous; for it is in the quantity and duration of this hæmorrhage that its value as a diagnostic sign of fracture of the base of the skull consists.

Vomiting of Blood may occur in these cases, from the blood having found its way through the fractured ethmoid or sphenoid down the nose and through the posterior nares into the pharynx and stomach. In these cases the vomited blood is dark, grumous, and mixed with the contents of the stomach. In some rare cases, the blood that issues from the nose and mouth passes into these cavities through the Eustachian tube. The petrous portion of the temporal bone is fractured, and the middle ear opened; the tympanic membrane, however, being unbroken, no bleeding from the external ear ensues, but the blood escapes into the pharynx through the Eustachian tube. In some cases there may be a combination of these different signs. Thus, in a patient of mine at the Hospital, there were hæmorrhage into the left orbit and from the left nostril, copious vomiting of blood, and bleeding from the right ear, following a blow upon the forehead. The diagnosis which was made during life, and which was verified after death, was a fissure of the skull extending through the left orbital plate of the frontal bone, the ethmoid, and probably the sphenoid on that side, and a fracture of the petrous portion of the right temporal bone.

2. The **Discharge of a thin Watery Fluid** from the interior of the skull sometimes occurs; and, when it happens, it is the most certain sign of fracture of the base that we possess. This discharge usually takes place through the ear; but it may occur from the nose, of which I have seen one instance, and Robert mentions another. Still more rarely it takes place from a wound in the scalp communicating with the fracture, percolating through this, and so being poured out externally. Cases of this kind have been described by Hey, O'Callaghan, Robert, Hewett, and other Surgeons. One such instance was communicated to me by one of the pupils of University College, a few years ago. A boy received a wound on the back of the head, with

depressed and comminuted fracture of the skull. On the nineteenth day after the receipt of the injury, a large quantity of serous fluid began to escape through the wound, and continued to do so profusely until his death from coma four days later. At first the fluid that is discharged is usually tinged with blood, but this soon ceases, and it then flows clear.

There would consequently appear to be three situations—the ear, the nose, and a wound on the vault of the cranium—from which this discharge has been observed. It is an exceedingly valuable though most serious sign; and Robert, who has investigated this phenomenon with much closeness, states that the cases in which it happens always terminate fatally. This, however, is an error; for a number of cases have occurred at the University College Hospital and elsewhere, in which the patients, adults, recovered, although many ounces of fluid were discharged from the ear. It is usually associated with symptoms indicative of serious injury to the base of the brain; but to this there are also exceptions, for I have seen it in cases of injury of the head, unaccompanied by any severe cerebral symptoms. Most generally it occurs in young people. Robert says that it does so invariably; but Hewett states that in most of the instances in which he has seen it the patients were above thirty years of age. In one of my cases, the patient was fifty-eight years of age; and in six other instances in which I have observed it, the patients were all adults. In all cases of recovery that I have witnessed, some deafness of the ear from which the discharge occurred has been left, though this does not seem to be an invariable consequence of the injury.

The *Quantity* of fluid that is thus discharged is always very considerable, the pillow usually becoming soaked by it, which may be the first thing to attract attention to it. It is often necessary to keep a piece of sponge or a pledget of lint against the ear, in order to prevent the fluid from wetting the patient as it trickles out; and, if a cup be so placed as to collect it, an ounce or two will speedily accumulate. Laugier states that he has seen a tumblerful discharged in a short time, and as much as twenty ounces have been known to be poured out in three days. The flow is usually continuous for several days, and then ceases.

Although the occurrence of a watery discharge from the ear after certain injuries of the head had been observed by Van der Wiel, O'Halloran, and Dease, in the early part and middle of the last century, no attention was paid to the subject by later surgical writers; and the subject appears to have been completely lost sight of until Laugier, in 1839, again directed the attention of Surgeons to this interesting phenomenon. Since this period, it has been often observed and attentively studied; and the nature and the sources of the discharge have been particularly investigated by Laugier, Chassaignac, Robert, Guthrie, and Hewett. Its *physical and chemical characters* are those of a perfectly clear, limpid, and watery fluid, containing a considerable quantity of chloride of sodium, with a little albumen in solution, and a trace of sugar. It is not coagulable by heat nor by nitric acid.

The **Source of this discharge** has been the subject of much speculation. Laugier believed it to be the serum of the blood filtered through a crack in the petrous portion of the temporal bone, and so through the ruptured membrane tympani. This explanation, however, is evidently not correct; for not only is blood extravasated in the living body incapable of this species of rapid and complete filtration, but the fluid differs altogether in chemical composition

from the serum of the blood; for it contains a mere trace of albumen and double the quantity of chloride of sodium. By others it has been supposed that the fluid is furnished by the internal ear, being a continuous discharge of the liquor Cotunnii; but its large quantity, and, above all, the fact of its occasionally escaping through the nose, demonstrate the fallacy of this explanation. Again it has been supposed, but without sufficient evidence, that the cavity of the arachnoid furnishes this secretion. But the arachnoid does not secrete sufficiently to furnish the quantity of fluid discharged; and if this membrane were irritated and the secretion increased, it would become opaque from lymph or pus admixed with it. I think, with Robert, that there can be no doubt that this discharge, in most cases at least, is cerebro-spinal fluid; for not only is it, in appearance and chemical composition, identical with this liquid, but there is no other source within the skull than the pia mater which can yield with equal rapidity so large a quantity of fluid; experiments on animals having shown that the cerebro-spinal fluid is rapidly reproduced after its evacuation. An additional proof of the identity of this discharge with the cerebro-spinal fluid is to be found in the fact pointed out by C. Bernard, that they both contain a trace of sugar. In order that the fluid be discharged, the membranes of the brain must have been torn opposite the outlet by which it is poured forth, in such a way as to open up the sub-arachnoid space. This has actually been ascertained to be the case, by carefully conducted dissections. When it is discharged through the ear, the laceration, as Bérard has remarked, must have extended through the cul-de-sac of the arachnoid, which is prolonged around the auditory nerve in the internal auditory canal. When it is poured out through the nose, the fracture has probably extended through the cribriform plate of the ethmoid bone, and laid open the prolongation of arachnoid that surrounds the filaments of the olfactory nerve.

The diagnostic value of watery discharge from the ear varies, according to Sir Prescott Hewett, with its relation to the hæmorrhage which may occur. He divides cases of watery discharge from the ear after injuries of the head into three classes.

In the first class, the discharge is watery from the first, and abundant, being preceded by little or no blood, and beginning immediately after the accident. This is undoubtedly cerebro-spinal fluid, which escapes through a fracture of the petrous bone implicating the internal auditory canal.

In the second class, there is copious and prolonged bleeding from the ear, followed by the watery discharge. Here, too, there is fracture of the petrous bone: but its exact situation is uncertain. In these cases, the diagnosis will rest upon the prolonged hæmorrhage, rather than on the watery discharge.

In the third class, there is but little bleeding after the injury, and the watery discharge, which is variable in quantity, varies also in the time of its appearance. In these cases the diagnosis must remain doubtful. He mentions two cases which occurred at St. George's Hospital in which a copious watery discharge flowed from the ear. In neither of these after death was any fracture of the petrous portion of the temporal bone found. In one the membrana tympani was ruptured, and the cavity of the tympanum was "intensely vascular;" in the other, "the discharge was connected with a fracture of the lower jaw just below the condyle: the lower fragment had perforated the wall of the meatus auditorius."

The facial nerve may be so injured by a fracture of the petrous portion of

the temporal bone as to become paralysed at the time of the accident. But more frequently paralysis of this nerve does not come on until a later period, about the second or third week after the injury, and disappears after lasting about a month. This transient facial paralysis, accompanying some forms of fracture of the base of the skull, has been studied by Marshall, who explains it as being occasioned by the pressure of inflammatory exudation, which gradually becomes absorbed as the fracture unites, and thus the compression of the nerve is removed after a time.

Treatment.—In the treatment of fracture of the base of the skull it must not be forgotten that whenever bleeding appears externally, the fracture is compound, and that decomposition of the discharges, with consequent septic meningitis, forms one of the greatest dangers of the case. Fortunately, however, in a large proportion of cases the dura mater is intact, and consequently the danger is greatly diminished. In fractures implicating the ethmoid and sphenoid bones, with hæmorrhage from the nose, nothing can be done to prevent decomposition. In fractures affecting the tympanum, with rupture of the membrana tympani, the prevention of decomposition is more hopeful, although the Eustachian tube communicating with the upper part of the pharynx causes some degree of uncertainty. Yet, as it is lined with ciliated epithelium, it is quite possible that the causes of decomposition may not reach the fracture by that route. The ear should in such cases be carefully syringed out with a solution of carbolic acid in water (1 in 30), and it may then be plugged either with carbolic gauze or iodoform-cotton-wool, a larger pad of the same material being placed outside and secured by a bandage. The syringing must be gently done, and the carbolic solution should not be too strong, or it may cause some inflammation in the middle ear. The dressing must be changed as often as may be necessary. We have yet to learn how much is to be expected from the antiseptic treatment of compound fracture of the base of the skull, but so far as reports have at present been published they are very encouraging. In other respects the treatment of fracture of the base of the skull must be conducted on those general principles that guide us in the management of simple fractures of the cranium, such as ice to the shaved head, a calomel purge, low diet, and absolute quietude in a darkened room. In many cases, the brain is so injured in its most vital parts that speedy death is the result. When recovery takes place, it is necessarily slow and protracted, liable to retardation from meningitis of an acute or sub-acute and chronic character.

Depressed Fracture of the Skull.—It occasionally though very rarely happens that, in consequence of a blow, a portion of the skull is depressed without being fractured, and even without any serious cerebral symptoms occurring. Such depression without fracture can, however, occur only in children, whose skulls are soft and yielding. In adults it cannot happen without the occurrence of partial or incomplete fracture. Many, if not all, of the so-called "congenital depressions" that are met with in the skull are the result either of violence inflicted on the cranium at birth, usually in instrumental labours, or of falls and blows upon the head in early infancy. Such depressions are smooth, concave, and sometimes symmetrical, and present very different characters from the irregular outline of an ordinary fracture. They never present the characters of a fissure ; there is no such thing as a congenital fissure of the skull.

In the **Diagnosis** of depressed fracture, it is important to remember that the apparent depression produced by an extravasation under the scalp may simulate this injury very closely. (See p. 713.)

Varieties.—Depressed fractures of the skull may either be simple, without wound of the scalp; compound; or comminuted. In the majority of cases, whether the fracture be simple or compound, there is comminution of the bone; the fragments being perhaps driven into the brain.

Sometimes, though very rarely, the **external table** alone is depressed and driven into the diploë. This is especially the case over the frontal sinuses, where it may be broken in, as I have seen happen from the kick of a horse, without the inner table being splintered, or any bad consequence ensuing.

The **inner table** may be fractured without any apparent injury to the outer table; and it may not only be so fractured, but a portion of it may be depressed, without the outer table being injured (Figs. 315, 316).

In all ordinary depressed fractures, both tables are depressed, but the internal table is splintered to a greater extent than the external one. This is

Fig. 313.—Fracture of the Skull from Gun-shot Injury from within: Splintering of Outer Table.

Fig. 314.—The same, natural size.

especially the case when the fracture is the result of gun-shot injury, or when it has been occasioned by blows with a pointed weapon, as the end of a pick, or a large nail, or the sharp angle of a brick. In these latter fractures, which constitute the dangerous variety termed **Punctured**, the outer table may be merely perforated or fissured, whilst the inner one is widely splintered into numerous fragments, for the extent of a square inch or more. This splintering of the inner lamina of the skull to a greater extent than the outer one has attracted much attention, being of considerable practical moment, and is often said to be owing to its being more brittle than the external table. This, however, I do not consider to be the only cause. I should attribute it rather to the fracturing force from without inwards losing a certain amount of momentum in passing through the outer table; the inner table being thus splintered more widely than the outer one, for the same reason that the aperture of exit made by a bullet is larger than that of entry. If this be the true explanation, the reverse ought to hold good if the force be applied in the opposite direction. It is very seldom that we have an opportunity of examining such a case; but, some years ago, a man was brought to the Hospital who had discharged a pistol into his mouth and upwards through the brain. The

bullet had perforated the palate and passed out at the upper part of the cranium, near the vertex. On examining the state of the bones, it was found that the outer table of the skull was splintered to a considerably greater extent than the inner one, showing clearly the influence of the *direction* of the fracturing force (Figs. 313, 314). This case led me to make further experiments on the dead body; and I found that the outer table is always more splintered when the blow is struck from the inside of the skull outwards.

Teevan has made a considerable number of ingenious experiments on this subject, by firing bullets and driving pointed bodies of various kinds through the skull. He finds, as the result of these investigations, that the aperture of exit is the larger, whether the blow be delivered, or the bullet be driven from without inwards, or the reverse. The explanation at which he has arrived is, that the aperture of entry is caused by the penetrating body only, whilst the aperture of exit is caused by this *plus* the fragments of bone driven out of that table of the skull which was first perforated. Thus, when a bullet strikes the external table from without, it first perforates this, and then carries along with it and through the inner table the fragments of bone that it has cut out of the external table, and hence fractures the inner table more widely than the outer. When both sides of the head are traversed by a bullet, it will be found that the aperture of entry in the *outer* table on the side first struck, and the aperture of entry in the *inner* table of the opposite side of the head, will be the smallest, the largest holes made by the bullet being the apertures on the inner table of the former side and the outer table of the latter. In the case of a large and broad body like a bullet, which carries a mass of fragments before it and does not merely perforate bone, Teevan's explanation is doubtless correct. But, in the ordinary "punctured" fracture, made, for instance, by the point of a nail being driven through the skull, it must be remembered that no fragments of the outer table or diploë are carried inwards, and that the very wide-spread splintering of the inner table, which is characteristic of this form of injury, cannot be accounted for in this way, but appears to me to be referable to the cause I have given—viz., the *direction* of the fracturing force and the loss of momentum in the breaking body. In addition to these two causes—viz., the loss of momentum and the action of the *débris* of that portion of the skull which was first fractured—there is a third reason why that table which is last perforated should be most splintered. It is this, that the table which is last struck is least supported and thus has a tendency to fracture over a larger area than that which was first penetrated. This explanation applies especially to ordinary punctured fractures inflicted by nails or other pointed bodies striking the head, and which neither lose momentum nor occasion *débris* in their passage through the skull. A familiar illustration of this is seen in driving a nail through a board. If the board is unsupported on its under side the nail will probably carry before it large splinters from that surface as it passes through the wood. But if the same board is supported on a block of wood and the nail driven through, then the aperture of exit will be as small as that of entry. Thus it would appear that in punctured or bullet-fractures of the skull in which the force acts from without inwards, the inner table is more widely splintered than the outer, from three causes, viz., loss of momentum in the bullet, the wedge-like action of the *débris* carried with it, and the insufficient supports furnished by the brain—the latter being a main factor in cases of ordinary punctured fracture. It

occasionally happens as the result of sabre- or hatchet-cuts on the head that a longitudinal incised fracture occurs, in which the outer table is merely notched, whilst the inner one is splintered along the whole line of blow. This is in point of fact an elongated punctured fracture, and the wide area of splintering of the inner table is due to the same cause as when a nail is driven in. In other cases, again, a portion of the skull is completely sliced off, hanging down in a flap of the scalp, and exposing the brain or its membranes.

A special and very important kind of punctured and depressed fracture is that in which, by the thrust of a stick, umbrella, or other blunt-ended body into the orbit, the orbital plate of the frontal bone, or the cribriform lamella of the ethmoid, is perforated, and the dura mater or brain wounded. In such cases there is sometimes no external wound, the stick having passed up under the upper eyelid; and it is conceivable that the same result might be

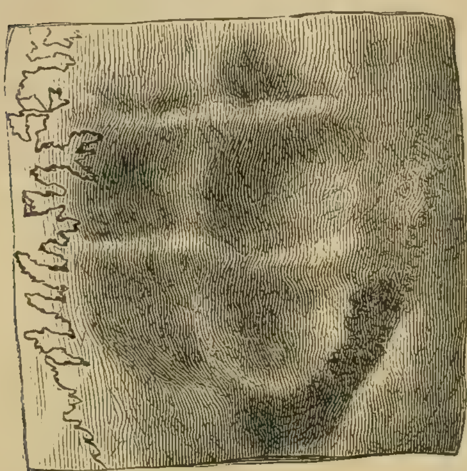


Fig. 315.—External Table Slightly Depressed.

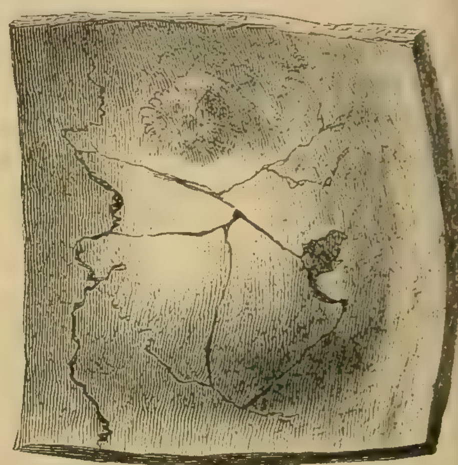


Fig. 316.—Internal Table Depressed and Fissured.

produced even by a thrust up the nostril. Death results either from wound of the cavernous sinus and intracranial extravasation of blood, or more remotely from septic meningo-encaphalitis following the wound of the dura mater and brain.

It is very important to observe that *the inner table may be very extensively fissured, and depressed, without any fracture of the outer table.* Of this remarkable injury twenty cases are recorded as having happened in the American civil war. One recovered, the diagnosis being made by finding the splintered inner table in a sequestrum which was removed. The rest died of intracranial mischief, and the diagnosis was not made during life. Most commonly when the inner table is thus fractured or depressed the outer table is fissured. The accompanying cuts (Figs. 315, 316), taken from photographs, of a preparation in the Army Medical Museum, Washington, represent a case of extensive gun-shot fracture with depression of the inner table of the left parietal bone without fracture of the external table. The patient was struck obliquely on the side of the head by a musket-ball, which inflicted a scalp-wound. There was no sign of cerebral disturbance until two days after the injury, when symptoms of compression set in. The skull was carefully examined through the wound for fracture; none could be found. The

symptoms of coma increased and proved fatal on the tenth day, when the inner table of the left parietal bone was found extensively starred and depressed (Fig. 316), without any fracture of the outer table (Fig. 315). There was a wound of the dura mater and an abscess in the cerebral hemisphere —in fact, all the appearances and sequences of an ordinary "punctured fracture." This interesting case demonstrates clearly the possibility of extensive fracture with depression of the inner table, whilst the outer remains unbroken.

The **Symptoms** of a depressed fracture of the skull are of two kinds: those that are dependent upon the injury to the bone, and those that result from the concomitant compression or laceration of the brain.

When the scalp is not wounded, the depression may sometimes be felt; but very commonly it is masked by extravasation of blood about it. In all cases of doubt, when these symptoms of compression exist, an incision should be made through the scalp at the seat of injury, and the state of the skull examined. When there is a wound in the scalp communicating with the fracture, the Surgeon detects at once the existence of depression and comminution by examining the bone with his finger through the wound. When the fragments that are depressed are impacted and firmly locked together, so as to form an unyielding mass, symptoms of compression of the brain, to a more or less marked degree, may result. But if the fracture be very extensive, and the fragments, though somewhat depressed, lie loose, and if they be yielding and do not exercise a continuous pressure on the brain, it occasionally happens that the symptoms of compression are entirely wanting, and no cerebral disturbance comes on for some days, even though the injury be very extensive. A man twenty-four years of age was admitted into University College Hospital, having been struck on the forehead with the sharp edge of a quoit. The frontal bone was extensively comminuted, twelve fragments being removed, and the dura mater being exposed to a considerable extent; yet no bad symptoms occurred until the ninth day, when inflammation of the brain and its membranes set in, and he speedily died.

In other cases again, more especially in children and young persons, in whom the bones are soft and yielding, fracture with depression may exist to a considerable extent, and no symptom whatever of compression be produced at any time—the patient living with a portion of his skull permanently beaten in. I have several times seen middle-aged persons with large flat depressions of the skull, the result of injuries sustained in childhood, who presented no signs of cerebral disturbance. It is rare, however, to meet with a recent case of depressed fracture in the adult without signs of compression of the brain. But, though rare, it is not impossible; and Green mentions the case of a man whose skull was depressed to the extent of the bowl of a dessert-spoon, without any symptoms of compression.

In cases in which the signs of compression are well marked, it must not be assumed that the pressure caused by the depressed fragments of bone is in all cases the sole or even the chief cause of the symptoms. It is scarcely possible for a man to suffer from a severe depressed fracture without serious bruising and laceration of the brain-substance beneath and a more or less extensive intra-cranial extravasation of blood. Both these conditions are important factors in producing the symptoms. The celebrated case so often quoted, in which Cline trephined a man who had been unconscious for thirteen months after a fall on the head, which caused a slight depression in the skull, restoring

him almost immediately to consciousness, will hardly bear investigation. The man had been pressed into the navy, and was consequently likely to feign disease to escape from it, and there are many cases of malingering on record quite as extraordinary as his. During the whole period of his insensibility he was able to make signs with his "lips and tongue" when he wanted food. This fact alone would be sufficient to throw the gravest doubts upon the genuineness of the case.

Wounds of the Dura Mater.—The great danger in cases of depressed and comminuted fracture arises not only from the compression of the brain, but from the rapidity with which inflammation so frequently follows the injury. This is due partly to the sharp fragments wounding and irritating the membranes of the brain, but chiefly to the septic matter which almost inevitably forms within the skull after these injuries, unless some means are taken to prevent it. In a compound depressed fracture the conditions present are as follows: Sharp fragments of the inner table are lying pressed against the dura mater, or possibly penetrating it, and opening the arachnoid cavity and subarachnoid space and wounding the brain; the fragments are surrounded by more or less extravasated blood, and in a few hours a considerable amount of inflammatory exudation will necessarily be added. All this decomposable material is in communication with the air through the fissures in the bone, and at the same time these fissures allow of but imperfect drainage from within the cavity of the skull. Consequently, the decomposing discharges are pent up and burrow within the cranial cavity. If the dura mater were not wounded at the time of the accident, it will inevitably be soon perforated by ulceration at the point at which the sharp fragments of the inner table, bathed in putrid pus, are pressing against it. In either case, the arachnoid cavity is opened and the septic matter diffuses itself widely within it, giving rise to the usual symptoms with the fatal termination characteristic of meningo-encephalitis. If the fragments are removed early and the external wound left open so as to provide perfect drainage from within the skull, the dangers of secondary perforation of the dura mater are very slight; and even should that membrane have been wounded at the time of the accident, the patient has a fair chance of escaping diffuse meningitis; for healthy inflammation with adhesion of the arachnoid may occur within a few hours, and thus present a barrier to the diffusion of any septic matter that may form afterwards. If, with the removal of sharp fragments and the provision of good drainage, we combine some perfect method of antiseptic treatment of the wound, the patient's dangers, though still great, will be reduced to a minimum. Indeed, a wound of the dura mater, however slight, is a most dangerous complication. This is more especially the case in those injuries in which the inner table is extensively splintered, as in the different forms of punctured fracture. In these cases there may be no signs of compression; but inflammation speedily sets in, and proves certainly fatal if the sharp spicula are not removed and good drainage provided for such discharges as may form within the cranium. In cases which are not thus relieved, the dura mater after death is found to be sloughy, and covered with a thick layer of puriform inflammatory exudation; whilst the usual evidences of meningo-encephalitis are found in the other membranes and the brain. Wounds of the dura mater, though in the highest degree dangerous, are not necessarily fatal. In military practice it has often happened that, as the result

of sabre-cuts, portions of the skull have been sliced or split down, the subjacent membranes and the brain itself being wounded, and yet a good recovery has resulted; and I have had several cases under my own care in which, though the dura mater has been punctured by spicula of depressed bone, and portions of brain lost, the patients have made good recoveries. In many of the cases in which recovery has thus taken place, the injury has been such as to provide efficiently for drainage of the wound without the interference of the Surgeon.

The **Treatment** of a depressed and comminuted fracture of the skull varies not only according to the nature and extent of the accident, but also to the existence or absence of symptoms of compression of the brain.

If there be no wound in the scalp, but the occurrence of symptoms of compression and the existence of some irregularity of the skull at the seat of injury lead the Surgeon to suspect a depressed fracture, he should make a crucial or ⊤-shaped incision down upon the part in order to examine the bone; and, if this be found depressed, he should elevate or remove it.

If the scalp be already wounded, all that need be done to ascertain the nature of the fracture, is to pass the finger very gently into the wound and thus examine the bone. If any fragments be lying loose, they should be picked out, as they can only excite injurious irritation; any bone that is driven below its level must be raised, and, if completely detached, removed.

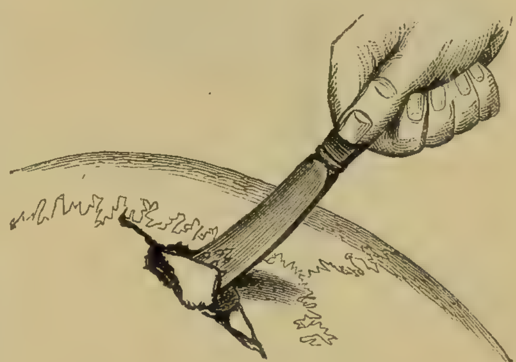


Fig. 317.—Application of Elevator.

In order to raise these depressed portions of bone, it is in many cases necessary merely to introduce the point of an elevator underneath the fragment, and, using the instrument as a lever, raise it into position (Fig. 317). If there be not an aperture sufficiently wide for the introduction of the elevator, one may be made by sawing out an angle of bone at a convenient spot by means of a Hey's or cranial saw (Figs. 318, 319), or by clipping off a projecting point with the bone-forceps. In this way, sufficient space may usually be gained without the necessity of applying the trephine. If, however, the inner table be splintered to a considerable extent, or if there be no convenient angle that can be removed, the trephine must be applied in such a way that at least half its circle is situated upon the edge that overhangs the depressed bone; the Surgeon sawing out by means of this instrument a portion of the undepressed skull, in order that he may more conveniently get at the fragment. After a half circle of bone has been removed in this way, the depressed splinters may be taken out, a Hey's saw still being occasionally required before the whole can be removed. It is interesting to note that the instrument familiarly known as Hey's Saw does not appear to have been invented, though it was largely used and described, by Mr. William Hey, of Leeds. He states ("Practical Observations on Surgery," London, 1814, p. 9), that the instrument was first shown him by Dr. Cockell, of Pontefract, and that a saw, formed on the same principle, is represented in Scultetus' Armamentarium Chirurgicum. In the works of Ambroise Paré (edited by Malgaigne, Vol. II., p. 14), will be found an exact representation of the instrument, with a straight edge, as depicted

by Hey, and as used at the present day. He says: "Par icelle on peut couper de l'os (sans comprimer dessus) tant ou si peu qu'on voudra, sans estre en danger de comprimer l'os fracturé sur les membranes et par consequent sur le cerveau."

In whatever way the operation be performed, the flaps of scalp should be laid down when it is completed, and a suture or two applied, care being taken not to sew up the wound so tightly as to prevent the escape of discharges.

On the introduction of the antiseptic method of treating wounds, some Surgeons hesitated to apply the strong solutions of carbolic acid used in that method to the membranes of the brain, and still more to the wounded brain substance, fearing that by so doing they might cause inflammation as fatal as that they desired to prevent. In order to furnish reliable evidence on this point,

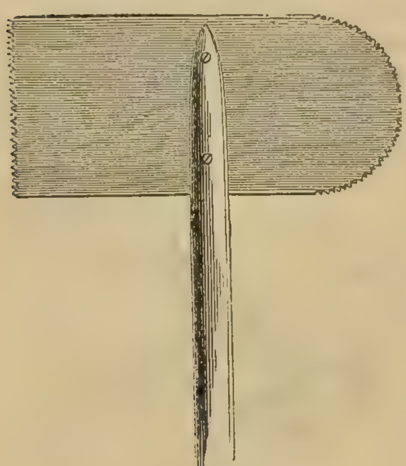


Fig. 318.—Hey's Saw.

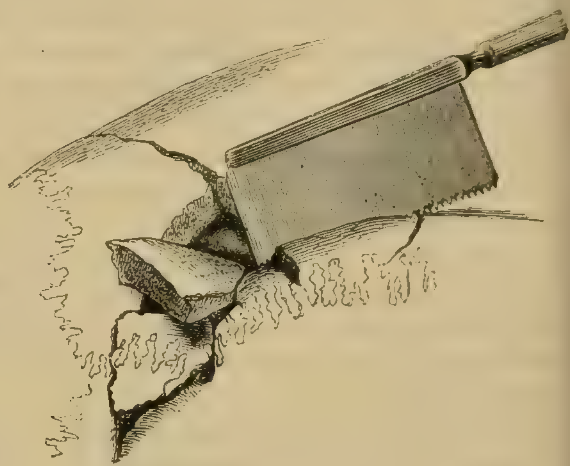


Fig. 319.—Application of Cranial Saw.

Gerald Yeo undertook a series of experiments on monkeys. In the first place, he showed that in almost every case in which the skull was opened by a trephine and portions of the brain-substance removed without antiseptic precautions, death speedily occurred from meningo-encephalitis. He then performed a series of 26 operations, following strictly all the details of Lister's antiseptic treatment; of these seven died, one from the chloroform, one from bleeding on the sixth day, one thirteen days after the operation without any signs of inflammation of the brain, three from the effects of cold weather, and one only from diffuse meningo-encephalitis. In many of these animals large portions of cerebral substance were cut away without causing any inflammatory disturbance beyond the area actually injured. The experiments showed conclusively also that a five per cent. solution of carbolic acid may be applied with impunity to the brain or its membranes.

The statistics given by Kramer, in an inaugural dissertation at Breslau in 1880, show no less conclusively the great advantages to be derived from antiseptic treatment. Of twenty-five cases of compound fracture of the skull with wound of the brain, in which no operation was performed, ten died, five from meningitis and one from pneumonia, and the rest directly from the injury to the brain. Of twenty-five cases of primary trephining for injury, only two died, one from circumscribed meningitis and one from diffuse meningo-encephalitis; in twenty-one the wound healed by first intention. Of

six cases in which secondary trephining was performed one only died with hernia cerebri. These results are certainly much better than any that had been obtained previous to the introduction of the antiseptic treatment into surgery.

The treatment should be thus carried out; the wound must as soon as possible be covered with a piece of linen rag soaked in a three per cent. solution of carbolic acid in water. The whole head is then to be shaved and carefully cleaned with soap and water. If necessary it may be sponged with a weak solution of ammonia to get rid of grease; but, of course, in doing this the liquids used in washing must not be allowed to flow into the wound. The head is then cleaned with the carbolic solution (1 in 30), and this may be allowed to enter freely into the wound. It must not on any account be forcibly injected, as by so doing it might become widely diffused in the arachnoid cavity or the brain might be injured. The wound being thus thoroughly cleaned, the carbolic spray may be turned on, and the operation of removal of fragments, or elevation if necessary, may be commenced. When this is completed the edges of the wound must be brought together, pared, if much contused and very dirty, provision being made for drainage, and the ordinary antiseptic gauze, or some other efficient antiseptic dressing may be applied. It is not always possible to render the wound thoroughly aseptic, as much dirt may have been ground into it, and some time may have elapsed before the case is seen; but the dangers of septic meningitis are so great that it is always worth while to make the attempt even in apparently hopeless cases. In country practice it will of course frequently happen that the carbolic gauze is not at hand; under these circumstances the wound, after having been thoroughly washed with carbolic acid lotion, may be dressed with carbolic oil (1 in 10), and during the time it is necessarily exposed in dressing it may be irrigated with the antiseptic solution. Failing all other antiseptic dressings, the wound may be washed out with spirit and water and dressed with dry lint or cotton wool, in the hope that decomposition of the discharges may be prevented by drying. The one thing that is more certain than anything else to ensure decomposition is washing the wound with common water and applying simple wet lint to it, as was formerly the universal practice.

All the precautions previously described as applicable to cases of injury of the brain, such as low diet, purging, perfect quiet, dry cold to the head, &c., must be employed as rigorously when the antiseptic treatment is adopted as when it is not.

From the success that has attended the treatment of depression of the skull without fracture, by means of pneumatic traction, it has been recommended in cases of simple depressed fracture, without injury of the brain or its membranes, to make an attempt to draw the depressed portion of bone to its normal level by means of a cupping-glass, adapted to the uneven surface of the skull by means of a cell of glazier's putty.

In all cases of **Punctured Fracture**, in which, as before stated, there is but slight injury of the external table, with considerable splintering and depression of the inner one, or when there is a narrow and deep depression of the bone, the trephine must be applied on different principles from those that guide us in its use in ordinary depressed fractures. In the punctured fracture it is applied, not to remove symptoms of compression which, in all probability, do not exist; but with the view of preventing the inflammation which will to a certainty be

set up if the splinters of the inner table and pent-up decomposing discharges be allowed to continue irritating the membranes and brain. Hence it is a rule in surgery, in all cases of punctured fracture, to apply the trephine at once. In these cases a trephine with a large crown should be used, and the circle of injured bone itself must be sawn away (Fig. 320). Should, however, the use of the trephine have been delayed in these cases until inflammatory action has been set up, the instrument may still be applied with advantage. Many years ago a boy was admitted into University College Hospital, on the sixteenth day after having been struck on the side of the head by a large nail, which projected from a door that fell upon him. No symptoms of any kind had occurred until the eleventh day after the accident, when he became dull and lost his appetite; on the sixteenth day, that of his admission, he had suddenly become drowsy and delirious, but answered rationally when spoken to, and complained of pain in the head. The pupils were dilated, the skin hot, and the pulse quick. On examination, a small round aperture, from which some fetid pus exuded, was discovered on the right parietal eminence. On introducing a probe, which the hole just admitted, some rough bone could be felt. S. Cooper immediately trephined the boy, removing a circle of bone including the small aperture. The inner table corresponding to this was found splintered to some extent, and the dura mater was thickened and inflamed; but the patient recovered without a bad symptom.

Fig. 320.—Trephined circle round Punctured Fracture. Natural size.

Linear Cuts, as by sabre or hatchet, into the skull, penetrating the outer table, are apt to splinter the inner one, in the same way as occurs in a "punctured" fracture, to which they bear a close analogy. They require the same preventive trephining that is needed in the true punctured fracture, having for its object the removal of splinters and spicula, which would infallibly produce a fatal meningitis if left.

In those rare cases in which there is a **Depressed Fracture, without symptoms of compression** or even a wound of the scalp, the rule of practice is somewhat unsettled, as to whether the depressed portion of bone should be left where it is, or an attempt be made to elevate it. Sir A. Cooper, Abernethy, and Dupuytren advise that, if it do not give rise to any symptoms of compression, it is better not to interfere with it; and there are several cases on record of patients who have recovered in whom this course was adopted, the depression continuing permanent. That non-interference is the proper course to pursue in some cases, more particularly in children, there can be no doubt. I have had under my care a child in whom, in consequence of a fall, there was on one of the parietal bones a depression as large as a crown-piece, its edges being sharply defined: no signs of compression or of inflammation of the brain ensued, and it was consequently left without interference, the child making an excellent recovery, and continuing well. Indeed, in children, the amount of injury that may be inflicted on the brain, not only by compression, but by actual laceration, and yet be followed by recovery, is very surprising.

In the adult, the cerebral substance does not accommodate itself so readily to injuries, and here the line of practice is not quite so definite. But even in persons of mature age, under certain favourable circumstances, bone may be

depressed and continue so without giving rise either to compression of the brain or to inflammation of its membranes. I had once under my care a case which illustrated this point forcibly. The patient, a middle-aged man, fell on his head into an area, and stripped off the greater part of the scalp from the anterior part of the head and the vertex; on the upper part of the left parietal bone was a starred and depressed fracture of the skull as large as a florin. As the depression was smooth, not more than a quarter of an inch in depth, and there was no symptom of compression, I drew the scalp forwards and left the bone untouched, the patient making an excellent recovery, without any symptom of intracranial mischief. I am acquainted also with a gentleman upwards of fifty years of age, who has a depression in the parietal bone as large as the bowl of a table-spoon, the result of a fracture by a fall from a horse when a lad, and from which no inconvenience has resulted. I think, however, that the expectant treatment should not be followed too implicitly, but that we must be guided by the circumstances of the particular case. If the depression be nearly uniform, of inconsiderable depth, and occupy a large extent of skull, which is depressed in a smooth hollow or bowl-like manner, and more especially if the patient be young and the scalp unwounded, it may be better doubtless to follow the advice of Cooper, Abernethy, and Dupuytren, and to wait for symptoms of compression manifesting themselves before we interfere. If, however, the scalp be wounded, the depression sharp, deep, and comparatively small in extent, we may reasonably suspect the existence of considerable splintering of the inner table; and here, I think, the safer plan would be, even in the absence of all symptoms of compression, to elevate for the same reason that we trephine in punctured fracture—the prevention of inflammation that would be occasioned by the irritation of the splinters of the inner table. I would not, however, venture to dogmatize on this very important and difficult point of practice. The opinions of the most experienced Surgeons are at variance; and cases may readily be adduced on either side in support of conflicting doctrines. It would appear that military Surgeons generally are in favour of the expectant plan, and cases may be found in the works of Guthrie and Ballingall in support of this practice; and it is a remarkable circumstance that, in many of those instances in which recovery resulted in cases of depressed fracture of the skull which were not subjected to operative interference, the patients were exposed to great privations, possibly during a hurried retreat, and left in circumstances apparently the least favourable to recovery. So far as my own experience is concerned, which is necessarily drawn purely from civil practice, I can say that, with the exception of the case that has just been referred to, I do not recollect ever having seen a case recover in which a compound depressed fracture of the skull occurring in the adult had been left without operation; but I have, on the other hand, seen several instances of recovery in which the bone had been elevated and fragments removed.

The sooner elevation is done the better. Danger does not arise from early operation, but from delay. The presence of depressed and spiculated fragments pressing into the dura mater must speedily induce meningo-encephalitis, and inevitably so if they become bathed in decomposing discharges. I have several times trephined primarily in such circumstances as these with success, and have never had occasion to regret doing so. Indeed, there is no class of cases in which the operation of trephining is attended by such successful results as in

those of depressed and comminuted fracture. Even though several days have elapsed and inflammation has set in, the proper treatment will be to remove the depressed and splintered bone, and thus give the patient his only chance—a slender one, it is true—of recovery. In such adverse circumstances the patient may, however, be saved. A man was admitted under Liston with a long depressed fracture on the side of the head, produced by the blow of a brickbat; though no sign of compression existed, yet symptoms of cerebral inflammation were speedily set up, and Liston trephined him on the fourth day after the accident; the man, who was perfectly conscious, walking into the operating theatre. A considerable splintering of the inner table was found, the fragments of which were removed. The dura mater having been punctured by one of the spicula of bone, diffuse suppuration of the membranes of the brain set in, and the patient died in a few days. In this case, however, the necessity for early trephining was clearly indicated, notwithstanding the absence of any symptom of compression.

The **Ultimate Results of Fracture of the Skull** in those who recover will more or less closely resemble the conditions given at p. 718, as the consequences of contusion of the cranium without fracture. Epilepsy was very frequent in the American war cases; so also partial or complete loss of vision was one of the common sequences of such injuries. When deafness occurred, it was generally connected with impairment of other special senses, and often of the mental faculties.

When a depressed fracture of the skull is **complicated with a Fracture or other Injury of the Spinal Column**, it is sometimes difficult to know which symptoms are due to the one accident, and which to the other. In such a case as this, however, we should, I think, treat the depressed fracture irrespectively of the spinal injury, thus giving the patient a chance of recovery, of prolongation of life, or, at least, of return of consciousness before death. A man was admitted under my care into the Hospital, with depressed fracture of the left parietal bone, and injury of the cervical spine, the precise nature of which could not be accurately determined. He was in a state of complete coma and paralysis. I trephined the skull and elevated the depressed portion of bone; he recovered his consciousness to a great degree, but died in a few days, apparently from injury to the spine. On examination after death, we found a fracture of the fifth cervical vertebra.

INJURIES OF THE CONTENTS OF THE CRANIUM.

Wounds of the Brain and its Membranes are frequent in injuries of the head, and are among the most important complications of these accidents. The extent of injury inflicted upon the cerebral substance has wide limits, from slight laceration without exposure, to denudation of the brain, disintegration, and escape of large portions of its substance.

Causes.—Injury to the brain may be occasioned in various ways. The simplest form is, perhaps, that which is frequently met with in undepressed fracture of the skull and sometimes happens without fracture, from simple concussion or commotion.

Under these circumstances the laceration of the cerebral substance occurs in most cases on the side of the head opposite to that on which the violence is applied, usually at a point exactly opposite to that struck; much less frequently

it is found immediately beneath the part of the skull which received the blow. Laceration of the brain is the commonest cause of death in simple fracture of the skull, the fracture itself when not compound being no more dangerous than a similar injury of any other bone. It is attended by extravasation of blood proportional to the amount of injury done to the brain-tissue, and in severe cases this is sufficient to give rise to symptoms of compression which completely mask any special signs of cerebral laceration.

The regions of the brain most commonly injured are the anterior parts of the frontal and temporo-sphenoidal lobes. This is due partly to the irregularity of the surfaces of the bones against which these lobes lie, but much more to the fact that the posterior and postero-lateral parts of the skull, and the vertex are the most exposed to injury from falls and blows. Thus when a person slips suddenly up in frosty weather and strikes the back of his head on the pavement there may be no external sign of serious injury, nor any fracture of the skull; yet laceration of the anterior portions of the cerebral hemispheres frequently occurs at the point exactly opposite to that struck.

The explanation before given of this fact—that the chief laceration is opposite the point struck—is that the blow starts a wave in the soft cerebral substance which breaks against the bone on the other side. In very rare cases it is possible to trace the course of this wave by hæmorrhages in the cerebral substance in its track. Thus not long ago a case occurred in University College Hospital in which a man received a blow from a fall on the left side of the forehead. He lived ten days, and at the post-mortem examination a bruise was found of the brain in the frontal lobe at the point which first received the violence, and exactly opposite this on the right occipital lobe was another bruise; in a straight line between the two bruises was a hæmorrhage into the right optic thalamus. Very sudden and violent blows, such as non-penetrating bullet-wounds, usually lacerate the brain immediately beneath the part of the skull struck, and some of the most typical cases of localized cortical injuries of the brain are consequently to be found in the records of military surgery.

The brain and its membranes are often lacerated by the *sharp spicula of a depressed fracture*, which may penetrate to a considerable depth in its substance. And, lastly, the injury may be occasioned by *foreign bodies*, such as bullets, traversing or lodging in the head; by sabre- or axe-wounds, or by *stabs and punctures* through the thinner portions of the skull, especially the orbital plate of the frontal bone. In this way a piece of stick, tobacco-pipe, the point of a knife, or a scissor-blade, may puncture the anterior part of the brain.

The **Post-mortem Appearances** of laceration of the brain vary with the degree of injury and the time the patient survives before death takes place. In a recent case every stage may be met with, from a mere superficial bruise, marked by a few points of extravasated blood in the grey matter, which still maintains its natural form and consistence, to extensive laceration and crushing, in which the grey matter, and a greater or less amount of the white is reduced to a pulpy, disintegrated mass, mixed with clots of blood. In the cases of simple bruising there is no extravasation of blood in the neighbourhood of the injury; in severe laceration clots are found superficially adhering to the injured part of the brain, and extending widely both in the sub-arachnoid space and the cavity of the arachnoid, sometimes completely covering one hemisphere with a thick layer of coagulum. Occasionally the extra-

vasated blood may have forced its way into the substance of the brain, and even have burst into the lateral ventricle ; but this is very rare.

If the patient survive beyond the third day, marked inflammatory changes may be found at the injured spot ; this is especially the case in lacerations due to penetrating wounds or accompanying compound fractures in which the dura-mater is torn. In these cases the brain-substance is softer than natural at the injured spot, and is washed away readily with a stream of water. At the injured part are the remains of the extravasated blood ; round about it the brain substance is redder than natural. In addition to the local mischief, the whole brain usually presents the appearances before mentioned, as indicating meningo-encephalitis ; the pia-mater is gorged with blood, and infiltrated with greenish, puriform, inflammatory exudation, starting from the injured spot and extending more or less widely in all directions ; there is a slight excess of cerebro-spinal fluid in some cases, but in others the surface is almost dry, and the convolutions are slightly flattened from swelling of the brain ; the grey matter is everywhere redder than natural, the red points seen in sections of the white substance are too numerous, and the ventricles often contain an excess of fluid. Supposing the patient to have escaped the immediate dangers of acute local inflammation and meningo-encephalitis, it is still possible that death may occur at a later period from softening round the injured spot. This softening is a result of the interference with the circulation from the injury to the vessels and the consequent hæmorrhage, and of the local inflammation following the injury. As the effect of this, the brain-tissue and the inflammatory exudation together undergo fatty degeneration, forming a yellowish pulpy mass, which washes away readily under a stream of water, the condition being known as yellow softening. The microscope shows innumerable fatty granules and granular cells, with sometimes recognizable *débris* of the nerve-fibres of the white matter. It is possible that recovery may take place even after softening of an area of some size, the degenerated tissue being absorbed and a small superficial defect left in the surface of the brain.

In cases in which recovery takes place without these unhealthy changes, a small tough, opaque scar, depressed below the surface, is left in the cortex, to which the membranes become firmly adherent. In the centre of the cicatrix may be a darker patch containing crystals of hæmatoidin, indicating its hæmorrhagic origin. If much blood have been extravasated into the cavity of the arachnoid, it occasionally happens that, instead of being completely absorbed, it becomes decolourized and partly organized, forming a layer often of almost leathery consistence and of dirty-brownish colour, which remains permanently adherent to one or both sides of the arachnoid space. Occasionally it forms a complete cyst, flattened out in the arachnoid cavity, and containing merely a trace of fluid. Such cysts are usually adherent to the dura-mater, but have been found loose in the arachnoid space.

Symptoms and Effects.—The symptoms and results of wound or laceration of the brain vary greatly according to the nature of the accident, the seat of the injury, the age of the patient, and other conditions which cannot always be very readily determined.

The ordinary symptoms of laceration of the brain are at first merely those of concussion already described (p. 698). As before stated, "concussion of the brain" is a clinical expression only, and probably in all cases in which the

patient rallies slowly, and certainly in those in which a return of consciousness is delayed over twelve hours, there is more or less bruising and laceration of the cerebral substance. If, as the patient rallies, the symptoms of concussion gradually merge into those of compression (p. 700), within twelve or eighteen hours, we may be sure that this is due to hæmorrhage within the skull, either from a laceration of the brain or from wound of a meningeal artery or a venous sinus. The diagnosis of this latter condition will be referred to further on. If soon after the injury cerebral irritation (see p. 700) sets in, we may be certain that laceration of the brain is present. Violent convulsions occurring within twelve hours of an injury to the head are almost invariably due to hæmorrhage from a laceration of the brain, either tearing down the brain substance in the region of the motor centres or diffusing itself widely in the arachnoid cavity. Lastly, impairment of function in any part of the brain, with the function of which we are acquainted, occurring as the direct result of injury, may be looked upon as evidence of bruising or laceration of that part. On the second day the temperature rises to about 100° F. in all cases of laceration of the brain, and by the third day it is usually 101° F. or 102° F., even when the air is excluded from the injured part.

If the case becomes complicated by septic meningo-encephalitis, the symptoms of this affection (p. 703) mask all those which are specially indicative of laceration. If the patient escape this danger he is still liable to local inflammation round the injured area. Supposing him to have regained consciousness, he will complain of fixed headache at the injured spot. This is especially marked if the laceration be in the anterior part of the frontal lobes. If Hitzig and Ferrier's motor area be affected, the commencement of local inflammation is frequently marked by violent convulsions; and alarming as this symptom is both to the Surgeon and the friends of the patient, it is by no means to be looked upon as a hopeless one. If between the fits the patient regains consciousness, there is still good hope of his recovery, especially if he is young and otherwise healthy. When the patient recovers, persistent localized paralysis or permanent loss of some mental faculty may be taken as conclusive evidence that the brain has been more or less severely lacerated. Suppuration round a lacerated area is indicated by gradual increase of the disturbance of function—as spreading paralysis, loss of consciousness, and perhaps convulsions—combined with the symptoms already given as indicative of the formation of pus within the skull (p. 709), coming on some four or five days, or even some weeks after the accident; but similar symptoms may occasionally arise from inflammatory or yellow softening without the actual formation of pus.

These being the general symptoms of laceration of the brain, it remains to be considered how they may be varied or modified by the nature of the injury and other circumstances.

The *Nature of the Injury.* If the brain be injured directly by some sharp-pointed or cutting instrument, as a sword or hatchet, the symptoms of concussion may be entirely wanting; the patient may not suffer from even momentary loss of consciousness. The same may occur when a blow with some angular body is received on the thin portions of the skull. Thus a young man was admitted into University College Hospital suffering from an injury to the brain which caused aphasia and facial paralysis, received in a fall against some steps. In spite of the severity of the injury he did not lose con-

sciousness, or, if he did, it was certainly for less than one minute. In punctured fractures the patient frequently walks to the hospital unconscious of having received any further injury than a cut head. It is not even uncommon to see a patient with a wound from which broken down fragments of brain substances are protruding, and who is yet perfectly conscious and has suffered only from a few minutes of insensibility. On the other hand, when the laceration is due to a more diffused blow on the head, in those cases in fact in which it is situated on the opposite side to that struck, concussion is almost always more or less distinctly marked. In these the injury is more diffused, and seldom at first capable of accurate localization, for in addition to the local injury the whole brain has been shaken and concussed. Under such circumstances, it is not surprising that the return of consciousness is often delayed for days or even weeks.

The *Locality of the Injury.* Until comparatively recently we had no means at our command by which we could with any certainty recognize the exact part of the brain which was bruised or lacerated by an accident unless the nature of the injury was such as to leave no doubt that the cerebral substance was wounded directly beneath the part of the skull to which the violence had been applied. It was known that injuries to one side of the brain caused paralysis of the opposite side of the body and face, and that sometimes the paralyses affected merely a part of one side, and were very temporary in their character; that in other cases extensive injuries of the brain were not accompanied by any interference with motor power; but there was no accurate knowledge by which the seat of the injury could even approximately be determined by the symptoms. The earliest definite attempt to localize an injury in the cerebral hemispheres was made by Broca, who pointed out in 1861 that the condition now known as aphasia, in which the patient loses the faculty of converting his ideas into articulate speech, is associated almost invariably with some definite lesion of the posterior part of the third left frontal convolution; but it is to the experiments of Hitzig in 1870 and 1871, and of Ferrier in 1873 and the following years, that we owe the full establishment of the doctrine of the localization of the cerebral functions. The observations of these Physiologists have been confirmed, and their important bearing on practical medicine and surgery demonstrated by the clinical and pathological researches of Charcot, Lucas-Championière, Bergmann, and many others. As the result of experimental observations upon the brains of dogs, monkeys, and other animals, it has been demonstrated that the cortical matter of the brain in the region of the sulcus of Rolando is the seat of various centres which are connected, in some way at present not fully understood, with the voluntary muscular movements of the body. Hitzig and Ferrier showed that if certain definite points in this area are stimulated by an extremely weak Faradic current definite groups of muscles on the opposite side of the body are thrown into action; when the strength of the current is increased the resulting movements are no longer accurately limited but extend to a whole limb or the whole side of the body; a still stronger current gives rise to a general epileptiform convulsion affecting the whole body and accompanied by loss of consciousness. Destruction of these definite areas causes paralysis of the corresponding group of muscles, but the evidence as to the permanence of this paralysis is somewhat conflicting. It seems probable that it is more permanent in the higher than the lower animals, as in monkeys Ferrier succeeded in per-

manently paralysing one side of the body by destruction of the cortical motor centres on the opposite side of the brain.

Clinical observations have shown that injuries of the convolutions in the region of the sulcus of Rolando in the human subject are accompanied by symptoms agreeing in every respect with those experimentally produced by Hitzig and Ferrier in animals. These symptoms may be divided into primary and secondary, according as they are immediately induced at the time of the injury, or appear later on as the result of inflammatory mischief around the injured part of the cortex. When, as the result of either primary or secondary mischief, a distinct group of muscles is paralysed, the term monoplegia is applied to the condition; when a similar group is thrown into spasm, it is spoken of as monospasm. Thus, if the upper limb alone is affected it would be described as brachial monoplegia, or monospasm, as the case might be. If a patient receive a blow upon the head, and, on recovering consciousness, it is found that a localized paralysis is present, we conclude that there exists a laceration of some severity in the cortical centre corresponding to the muscles implicated. If almost immediately after the injury there is a distinct spasm, affecting a localized group of muscles, a monospasm, we conclude that hæmorrhage is going on from the lacerated brain substance, and irritating or breaking down the tissue of the centre corresponding to the affected muscles; if the monospasm extends, first affecting the whole side of the body and finally both sides, so that the attacks assume the form of true epileptic fits, it is probable that the extravasated blood is extending over the surface of the brain and irritating more or less widely the whole motor area. As shown, however, by the experiments before mentioned, it is not necessary for both sides of the brain to be injured in order to produce a general spasm; a violent irritation at one spot only is sufficient. Consequently it is possible that such convulsions might be caused by hæmorrhage breaking down the brain-tissue in a limited area. The convulsions in these cases usually assume a regular course; the fit commences by twitching of that part which, in the intervals of the fits, is most clearly paralysed; thus, in an injury in which the centre of the right side of the face is chiefly affected, and in which facial paralysis is well marked, the fit commences by twitching of the right side of the face, then the head is turned forcibly to that side, then the right arm enters into the spasm, then the right leg, after which the left leg, left arm and left side of face are affected in the order mentioned. During the spasm the muscles of respiration become fixed, the face becomes livid, and the patient froths at the mouth as in a genuine epileptic fit. The attacks of convulsions often occur in rapid succession, and after each the paralysis may be found to have extended; the return to the normal state between the fits may become less and less perfect, and finally coma may set in. In such a case if coma is complete within twenty-four hours of the accident hæmorrhage from a laceration might be diagnosed with tolerable safety, and the question of trephining might arise, the site of the operation being determined, not by the situation of any external wound or bruise, but by the indications of cortical lesion furnished by the paralyses and spasms. It may happen, however, that the convulsions may not come on till the third, fourth, or fifth day. They are then in some cases of compound fracture due to septic meningitis extending over the motor area. In cases without an open wound convulsions at this period are due to inflammatory hyperæmia extending

round the injured spot. In favourable cases this frequently subsides, and the patient recovers; but in others it goes on to serious inflammatory œdema of the brain-substance, the convulsions increase in intensity and are repeated more frequently, the return to the normal state between the fits becomes less and less perfect, and finally coma sets in and death occurs. If the laceration be situated near, but not in the motor area, there may be no paralysis till after the convulsions, and the paralysis may then gradually extend after each convulsion, indicating the gradual spread of the inflammation into the region of the motor centres. In other cases again, the superficial motor centre may be affected at a much later period by the formation of an abscess in the substance of the brain. It is in these cases, perhaps, that the study of the localization of the functions of the cerebral hemispheres is of the greatest importance, enabling the Surgeon to determine the exact seat of the

Fig. 321.—Convolutions of the Brain; S. Fissure of Sylvius; *Sa*. Anterior Limb; *Sb*. Posterior Limb of Fissure of Sylvius; R. Fissure of Rolando; PO. Parieto-occipital Fissure; I P. Inter-parietal Fissure; PT. Parallel Fissure; SF. Superior Frontal Sulcus; IF. Inferior Frontal Sulcus; F 1, F 2, F 3. Superior, Middle, and Inferior Frontal Convolutions; F 4. Ascending Frontal Convolution; P 1. Ascending Parietal Convolution; P 2. Superior Parietal Convolution; P 3. Supra-marginal Lobule; P 4. Angular Convolution; TS 1, TS 2, TS 3. Superior, Middle, and Inferior Temporo-sphenoidal Convolutions; O 1, O 2, O 3. Superior, Middle, and Inferior Occipital Convolutions; R″. Broca's Convolution. (From Lucas-Championière.)

secondary lesion. In the primary lesion, the external injury of the scalp or skull will often suffice to lead the Surgeon to a correct estimate as to the seat of the injury to the brain; but in secondary or consecutive disease, such guides may be entirely wanting.

The following is a short summary of the combined results of experimental, clinical, and pathological observations as applied to the human brain.

1. **Aphasia** is dependent on a lesion of the posterior extremity of the third or inferior frontal convolution of the left side—Broca's convolution (Fig. 321, between F3′ and R″).

2. **Facial Paralysis** depends on a lesion of the lower third of the ascending frontal convolution (F4), and the contiguous part of the posterior end of the second frontal. The anterior part of this area is chiefly concerned in the movements of the upper part of the face. The posterior part, which extends to the lower third of the ascending parietal convolution, controls the movements of the lip and mouth. The fact that these centres are close to Broca's convolution, explains the frequent combination of facial palsy and aphasia.

3. **Paralysis of the Upper Limb** or brachial monoplegia indicates an affection of the middle portion of the ascending frontal convolution, and the contiguous part of the ascending parietal on the other side of the Sulcus of Rolando (about the spot marked R′). This centre being immediately above those for the face, it is common to meet with a combination of facial palsy and paralysis of the arm.

4. **Paralysis of the Lower Limb** indicates a lesion of the upper extremity of the ascending parietal convolution, and of the posterior parietal lobule lying behind it, and reaching to the margin of the longitudinal fissure (P2).

The foregoing localizations are agreed upon by almost all observers; but about some others, there is a difference of opinion. Ferrier states, that in front of the centres for the upper limb, in the superior frontal and part of the middle convolutions, reaching to near the longitudinal fissure of the brain is a

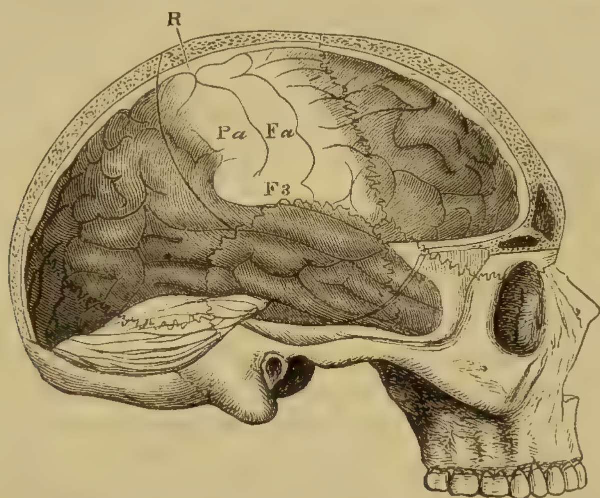


Fig. 322.—The Relation of the Convolutions to the Bones and Surface of the Skull. R. Fissure of Rolando; *Pa.* Ascending Parietal; *Fa.* Ascending Frontal Convolution; F3. Broca's Convolution. (From Lucas-Championière.)

centre which controls lateral movements of the head and eyes and dilatation of the pupil, the oculo-motor centre. He states also that there is a centre for vision along the lower part of the parietal lobe, and one for hearing in the first or superior temporo-sphenoidal.

The above facts may be made more clear by a few typical cases.

In 1881, a young man, age 20, was admitted into University College Hospital on the second day after he had received a rather violent blow on the left temple in a fall from some steps. On manipulating his head, a sensation was felt as if a small round piece of the thin part of the bone in that region had been broken loose; it was not depressed, and as further manipulation seemed dangerous, pressure was not repeated on it. He was not stunned by the accident, or at most for a few seconds only, but immediately lost the power of speech; he could understand what was said to him, but could say "yes," and "no," and nothing more. On the third day there was distinct paralysis of the lower facial muscles on the right side; on the fifth day, a clonic spasm commenced in the lower facial muscles, and gradually extended to the upper, and he lost consciousness. This lasted nearly half an hour, when he recovered, and was leeched over the injured spot, after which he fell

into a sound sleep, and from that time rapidly improved, being practically well by the fifteenth day.

A gentleman, age 39, was thrown from his horse, striking his head violently on the ground. He was taken up insensible, and was found to have a considerable extravasation in the right occipital region ; there were no signs of fracture. He soon regained partial consciousness ; he was quite unable to speak, and did not seem to recognize anyone, but from the first he got out of bed to make water, and showed signs of discomfort when he wanted to use the bed-pan. On the second day, he was restless and his mental condition the same. On the fifth day, he could give the right or left hand when asked, though his mind was very far from clear ; his speech was, however, evidently worse than the state of his mind could account for ; he used only a few words, repeating them frequently ; there was no paralysis. On the sixth day, he had violent convulsions, commencing with twitching of the right side of face, followed by turning of the head to the right, a rigid spasm of the right arm, then of the leg ; the spasm then became clonic and affected the left leg and arm, and finally the left side of the face. Between 10.30 A.M. and 2.30 P.M., he had twenty-one convulsions ; his head was shaved, and he was leeched, and the convulsions ceased. The following day it was noticed that the right side of the face was paralysed. From this time his recovery was slow, but uninterrupted. It was many months before he regained the full use of words, and during that time he was haunted by an idea which he could not explain. Six months after, he had a violent epileptiform fit, preceded by aphasia, lasting some minutes, but he recovered without any evil consequences ; he was suffering at the time from dyspepsia and constipation. On the first anniversary of his accident, he had a similar fit, from which time till the present he has remained well.

In the surgical history of the American war is recorded the case of a man who received a bullet-wound grazing the skull from the upper part of the frontal region to the vertex. The right arm was immediately paralysed, at first only partially, but gradually the whole limb became powerless. Nine months after the wound he was, however, well enough to be returned to duty.

Guthrie records a case of a soldier, aged 40, who was wounded at Waterloo by a bullet, which passed across his head close to the vertex, fracturing and depressing both parietal bones. He was stunned by the blow, and when he recovered found he had lost power in both legs. He was trephined ten days after the battle and made a good recovery, ultimately regaining much power in his legs.

These cases sufficiently illustrate the chief clinical features of injuries affecting the motor region of the cortex of the hemispheres. On each side of this motor region is an area the functions of which are not yet ascertained. It is well known that large portions of the anterior parts of the frontal lobes may be lost without the patient showing any appreciable change either mentally or physically ; of the occipital region even less than this is known.

As these cases may require the use of the trephine, it is of great importance that we should be able clearly to answer the question whether the paralysis is dependent on central or cortical lesion. If due to compression of a central ganglion, it is obvious that the trephine would be useless. In these cases the paralysis will probably have been immediate, its completeness will be very marked, and the whole of one side of the body at least will in all probability suffer.

In *cortical lesions*, in which the trephine may sometimes be advantageously applied, the paralysis, although it may be present immediately after the accident, often does not appear for some time; it is less complete and less extensive, sometimes affecting single groups of muscles.

The *Age of the Patient* exerts some influence on the symptoms and course of a case of laceration of the brain. Children, especially, have been known to bear extensive injuries of the brain, and even the loss of a considerable quantity of cerebral matter, without any very serious effects, either immediate or remote; and it is by no means uncommon to see them live several days with an extent of injury to the brain which would rapidly have proved fatal to an adult. Indeed it may be stated generally, that the younger the patient, the greater the chance of recovery. So, also, the prognosis may be considered more favourable in men of the labouring class, whose minds are but little exercised, than in persons of more cultivated intellect.

Foreign bodies even of large size and considerable weight have been lodged for a considerable time within the skull, in contact with the brain, without occasioning death. Thus Hennen states that he has seen five cases in which bullets were lodged within the skull, that did not prove immediately fatal. Cunningham relates the case of a boy who lived for twenty-four days with the breech of a pistol, weighing nine drachms, lying on the tentorium, and resting against the occipital bone. O'Callaghan has recorded the remarkable case of an officer who lived about seven years with the breech of a fowling-piece, weighing three ounces, lodged in the forehead; the right hemisphere of the brain resting on the flat part, from which it was separated only by false membrane. Guthrie records two cases in which, although a ball had lodged in the brain, the patients apparently recovered. Both, however, died suddenly when drunk within a year after having received the wound. In one who lived almost exactly a year, the bullet was found in a sort of cyst lying in the corpus callosum; in the other, who lived only a few months, it was lodged deeply in a cyst in the posterior lobe of the brain.

The **Diagnosis of Cerebral Laceration** varies much in difficulty, for, as before stated, the special symptoms indicative of laceration may be masked by those of compression or septic meningo-encephalitis. A careful consideration of the history and all the features of the case will, however, usually enable the Surgeon to come to a conclusion as to the presence of laceration; long-continued insensibility without coma, convulsions, irregular and localized paralysis and spasms, are amongst the most important signs. Cerebral irritation may be looked upon as always indicating laceration. Some confusion may occasionally arise from the fact that the paralysis or convulsions resulting from a cerebral lesion are always manifested on the side of the body opposite to that on which the injury to the brain exists; but not necessarily opposite to that on which the blow has been inflicted on the head; for the injury to the brain may, by counter-stroke, be in that cerebral hemisphere which is opposite to the side of the head that has been struck. Thus, if a person struck on the right side of the head sustain a rupture of the middle meningeal artery, and have extravasation of blood on the right hemisphere of the brain, he may have hemiplegia on the left side, and *vice versâ*. But, if the blow that is inflicted on the right side give rise to extravasation by counter-stroke on the left side of the head, the paralysis would develop itself on the side that had been struck. So it is with convulsive movements; they will occur in the arms and

legs, on the side opposite to that on which the brain has been injured, whether that injury be on the side struck from direct violence, or on the opposite side from counter-stroke. In this way the hemiplegia may occur on one side, and the convulsions on the other. A man was struck a violent blow on the *right* temple. He was seized with hemiplegia and facial paralysis on the *left* side, and with convulsive movements of the *right* side of the face, the *right* arm, and leg. He died a few days after the injury. On examination, we found a fissure of the right parietal bone, laceration of the middle meningeal artery, and a large clot pressing on the *right* side of the brain : hence the hemiplegia on the *left* side of the body. There was laceration of the middle lobe of the brain on the *left* side: hence the convulsive movements of the *right* side of the face, body, and limbs.

The **Prognosis** in wounds of the brain varies greatly according to the part that is injured, the nature of the injury, and the age of the patient. The danger is greatest and most immediate in injuries which affect the base of the brain, the pons, cura cerebri or medulla; it is least when the upper and anterior part of the hemispheres is the seat of lesion. Lacerations with open wounds, or compound fractures of the skull, or with penetration of a foreign body, are necessarily much more dangerous than those unaccompanied by such complications. Age exerts a very marked influence on the prognosis; the younger the patient the more hopeful the case, other conditions being equal. The following may be looked upon as grave symptoms: early violent convulsions, extensive paralysis, and the early supervention of coma; a very high temperature with great restlessness. The later convulsions about the fifth day, although grave, are by no means hopeless symptoms; they become grave if they are frequently repeated, and if in the intervals there is found to be an extension of any paralysis that may be present, and especially if the condition of insensibility is found to be gradually deepening after each attack. When the symptoms of intra-cranial suppuration set in, the case, although desperate, is not quite hopeless.

Treatment.—In the treatment of injuries of the brain, little can be done after the system has rallied from the shock, beyond attention to strict antiphlogistic treatment, though this need not be of a very active kind. In these cases, indeed, as much should be left to nature as possible, the Surgeon merely removing all sources of irritation and excitement from his patient, and applying an antiseptic dressing when there is a wound.

If any foreign body be lodged in the skull, it must of course be removed, if possible. This may be done if it be situated near the external wound, or fixed in the bone; but if it have penetrated deeply into the substance of the brain, and have gone completely out of reach, it would be perhaps more dangerous to trephine the skull on the chance of reaching it, or in any other way to go in search of it, than to leave it where it is. Bullets should always be extracted if they can be found. On this point military Surgeons are agreed. If they enter the skull, and strike against and fracture the opposite side without escaping, should they be sought for? I think not. Larrey and Bell, it is true, have extracted the ball on the side of the head opposite the point of entrance. But it may not be found there. In a case of suicide to which I was called some years ago, a gentleman had shot himself through the right temple: immediately opposite the wound, on the left temple, was a raised, loose, and stellate fracture of the skull, over which the scalp was uninjured. I cut down

on this and removed the fragments of bone, expecting to find the ball beneath them; but in this I was disappointed, and after death the bullet was found lying in the base of the skull, whither it had rolled. All operations performed in such cases should be carried out with strict antiseptic precautions.

In cases of laceration of the brain without open wound nothing is required at first beyond keeping the bowels open, applying cold to the head, and perfect quiet. Should there, however, be early convulsions or paralyses sufficiently definite to indicate the seat of the lesion, followed rapidly by coma threatening death, and evidently due, from its early occurrence, to hæmorrhage from a laceration, the question of trephining over the point of injury to the brain may arise. So far such treatment has not been sufficiently successful to encourage Surgeons to adopt it, but we have yet to learn what may be hoped from the operation performed with antiseptic precautions, and guided by our increased knowledge in localization of the injury.

When the convulsions and paralyses occur at a later period, and are sufficiently defined to enable the Surgeon to localize the seat of the injury, the head should be shaved, and leeches applied over the seat of the laceration, and after this an ice-cap. If the pulse be full and hard, and the patient young, blood may be taken also from the arm. The bowels should be freely acted on by some brisk purgative. Bromide of potassium may possibly be of use. As the result of these measures, the symptoms in many cases speedily subside. Should the convulsions become more violent and general, the paralysis more extensive, and the state of insensibility deeper, the question of treatment becomes more anxious. The extension of the mischief is probably due to inflammation extending around the laceration; and this being the case, can any good result be hoped for by trephining over the lacerated spot, guided by the theory of localization of the functions of the hemispheres? It is possible that tension might thus be relieved, and serum or clot allowed to escape, but the result would be very doubtful. At any rate the operation could be justifiable only when the case was otherwise hopeless.

The operation is, however, much more hopeful, and certainly should never be neglected, when symptoms of intra-cranial suppuration supervene with localized paralysis sufficiently defined to indicate the part of the cortex affected.

The guide to the application of the trephine in these cases is the *line of the Sulcus of Rolando* (Fig. 323) *on the side opposite to that in which the paralysis exists*, the exact spot in this line being determined by the seat of the paralysis. Lucas-Championière lays down the following rules for the application of the trephine.

1. When there is general hemiplegia, the crown of the trephine should be applied across the middle of the line of the Sulcus of Rolando.

2. When the arm and leg are paralysed, the trephine should be applied to the upper part of that line, but not at its very summit.

3. In paralysis of the upper limb only, the trephine should be applied a little in advance of the middle-third of the line.

4. In simple aphasia it must be applied lower down, below and a little in front of the line.

5. When both lower extremities are paralysed, the top of the line and the vertex must be trephined.

6. When the upper and lower extremities are paralysed, the middle and upper part of the line should be trephined.

7. Paralysis of one upper extremity with facial paralysis requires trephining in front of the line at its lower third.

8. Paralysis of one upper extremity with aphasia requires the trephine to be applied below and in front of the line.

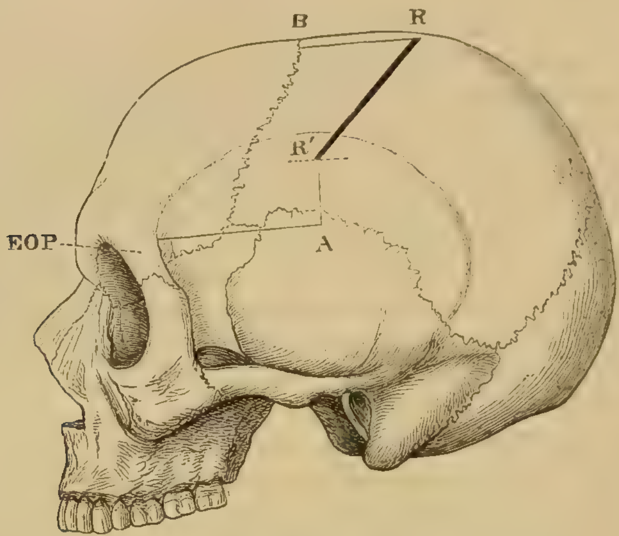


Fig. 323.—Guides for finding the thin Line of the Fissure of Rolando. (Lucas-Championière.)

9. In facial paralysis and aphasia the trephine must be applied in front of the line and below its level.

In all cases a large trephine should be used, and if necessary it may be applied in more than one place.

Various rules are given for finding the line of the Sulcus of Rolando.

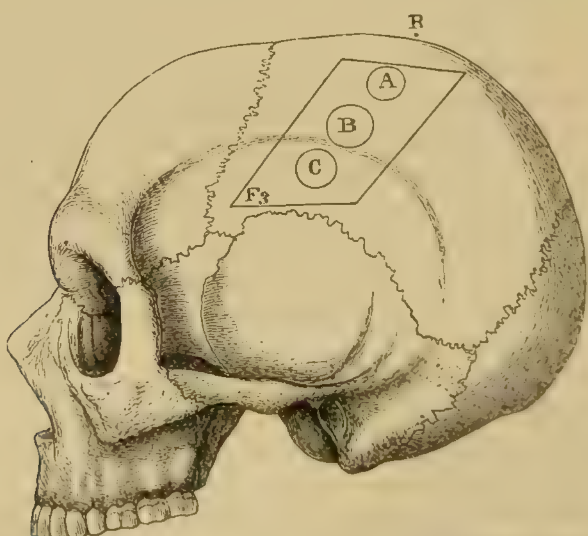


Fig. 324.—Situations in which the Trephine may be applied. A, for the centre of the lower limb; B, for the upper limb; C, for the centre of the face; F 3, Situation of Broca's Convolution.

Lucas-Championière gives the following: a point 55 millimeters behind the junction of the coronal and sagittal sutures in the middle line corresponds to upper end Fig. 323, R); to find the lower end (Fig. 323, R′), draw a line

directly backwards from the external angular process of the frontal bone for 7 centimeters (Fig. 323, EOP-A); from the posterior extremity of this, draw a vertical line 3 centimeters in length (Fig. 323, AR′), the upper end of this corresponds to the termination of the Sulcus of Rolando.

Thane gives the following: "The upper end of the Sulcus of Rolando is placed about half an inch behind a point mid-way between the root of the nose and the external occipital protuberance; its lower end is close to the posterior limb, and about an inch behind the bifurcation of the fissure of Sylvius. The bifurcation of the fissure of Sylvius corresponds to a point one inch and a quarter behind and a quarter of an inch above the level of the external angular process of the frontal bone."

Saccharine Diabetes is an occasional consequence of injuries of the brain. A man 43 years of age was admitted into Hospital under my care with paralysis, the result of a fall on the back of his head. On examining his urine, it was found to contain sugar in very large quantity. Previously to the accident, he had been perfectly well and robust; and, as the paralytic symptoms disappeared, the diabetic sugar gradually lessened in quantity, until it ceased entirely to be formed, and this notwithstanding the continued use of saccharine and amylaceous matter in the food. Claude Bernard has recorded some similar instances in illustration of the interesting physiological fact pointed out by him, that in rabbits wounds or irritation of the central portion of the medulla oblongata, between the origins of the vagus and the auditory nerves in the floor of the fourth ventricle of the brain, occasion saccharine diabetes, and that in the dog artificial traumatic diabetes may be induced by fracture of the skull and injury of the brain.

In patients already suffering from diabetes, a blow on the head is frequently followed by fatal aggravation of the complaint.

The **Cerebral Nerves** are occasionally injured at their roots, or torn across and detached from their connexion with the brain, in injuries of the head. These nerves may be wounded by the same violence that injures the brain, as when a bullet traverses the head; or they may be detached from their connexion with the brain in laceration of the cerebral pulp; or, lastly, they may be torn across in fracture of the base of the skull, by the fissure extending across the foramen through which the nerve passes.

From these causes, or from extravasation of blood into its sheath, blindness may result from injury to the optic nerve at any part of its course; ptosis, and strabismus in different directions, according as the third, the fourth, or the sixth nerve has been injured. But the nerve that most commonly suffers is the seventh, which, either in its facial or in its auditory portion or both, is not uncommonly torn across in fractures of the petrous portion of the temporal bone, producing either paralysis of the face or deafness. Injury to the eighth nerve is not common, or rather it is not common for patients long to survive who exhibit evidence of the lesion. I have, however, seen repeated vomiting, with palpitation, and a sense of suffocation continuing for months after apparent injury to the origins of the pneumo-gastric. In other cases, from lesion to the spinal accessory, spasm of the trapezius and sterno-mastoid muscles, simulating tetanus, may set in.

Hernia or Fungus Cerebri.—In those cases in which a laceration of the brain and dura mater communicates with a fracture of the skull, it is occasionally found, more particularly in children, that a dark brown or bloody fungus-

looking mass of cerebral matter protrudes from the wound. The period after the receipt of an injury at which this protrusion takes place, varies from a few days—eight or ten—to several weeks. It has been remarked by Guthrie, and the observation has been fully confirmed, that hernia cerebri is more likely to take place through small than large apertures in the cranial bones.

The protrusion is always the result of abnormal intra-cranial pressure, from inflammatory swelling of the brain-substance round the injured spot, or occasionally from the formation of an abscess in the hemisphere. As the protrusion increases in size, it becomes partially strangulated by the narrow opening through which it passes, and its size becomes increased by œdema, and by hæmorrhage and effusion into its substance. Thus the tumour increases rather

Fig. 325.—Hernia Cerebri following Compound Comminuted Fracture of Right Parietal Bone.

rapidly, pulsates synchronously with the brain, and may shortly attain the size of a hen's egg, or become even larger (Fig. 325). In its composition and structure it varies. In some instances it is composed chiefly of extravasated blood; but the true fungus cerebri is composed of softened and disintegrated cerebral matter, infiltrated with inflammatory exudation and blood. Softening of the brain, with red discoloration, extends for some little distance under the base of the tumour. The mental condition of the patient is in many cases not much disturbed at first, there being merely some degree of cerebral irritation. Speedily, however, stupor comes on, and death in most cases eventually occurs from encephalitis, ending in coma, consequent on the inflammatory effusions that take place within the skull.

Although the prognosis in fungus cerebri is extremely bad, it is not hopeless. In the American war seven cases of recovery are recorded. In the Italian war of 1859, Demme saw five recoveries out of twenty-one cases.

Treatment.—Preventive treatment is of the greatest importance, for if the complication be once established, its cure is very uncertain. The rigid antiseptic treatment of the wound by some efficient method is the only real pre-

ventive means at our command; if by this we succeed in warding off spreading inflammation in the brain-substance round the laceration, there will be no tendency to hernia cerebri. Should the fungus form, the treatment is extremely unsatisfactory. If the tumour be shaved off, as is usually recommended, it generally sprouts again until the patient is destroyed by irritation and coma conjoined. In some fortunate cases, however, the removal of the tumour is not followed by its reproduction. All that can be done is to slice off the growth on a level with the brain; to apply a pledget of dry lint, and a compress and bandage over the part, thus allowing it to granulate and the wound to cicatrize.

Extravasation of Blood within the Skull commonly occurs in all injuries of the head accompanied by laceration of the brain, and in many of those in which the skull is fractured without that organ being injured. Indeed, when we reflect on the great vascularity of the parts within the skull, the large sinuses, the numerous arteries that ramify both within the bones and at the base of the brain, and the close vascular network extended over the surface of this organ, we can easily understand that extravasation of blood is one of the most frequent complications of these injuries and a common cause of death, when they terminate fatally at an early period after their occurrence.

Causes.—Intracranial extravasation of blood may take place either with or without fracture of the skull. When it is the result of fracture, it is in consequence of the fissure tearing across one of the meningeal arteries distributed on the inside of the skull, or of a fragment of bone wounding a sinus or the vascular network on the surface of the brain; or it may proceed from laceration of this organ breaking down its capillary structure. In other cases, as in gunshot-wounds, the hæmorrhage may be a consequence of wound of the vessels by the bullet or other foreign body; but it may be the result also of apparently trifling injuries of the head without wound of scalp, or fracture of skull, from the rupture by concussion of one of the meningeal arteries.

Situations.—The extravasation may occur in four situations: 1. Between the dura mater and the skull, where it is most commonly met with; 2. Within the cavity of the arachnoid; 3. Upon the surface of the brain; or, 4. Within its substance and its ventricles. It is usually most considerable when poured out upon the dura mater, or within the cavity of the arachnoid at the base of the brain. It is in smallest quantity immediately on the surface of that organ, or within its substance. It is, however, seldom found in the latter situation as the result of violence, without being met with more superficially. The quantity effused in any one case seldom exceeds four ounces; and, when in such large quantity, it proceeds usually from rupture of the meningeal artery. I have once seen a clot from rupture of the middle meningeal artery that weighed five ounces and a half.

Results.—Extravasation of blood is one of the most frequent causes of death in injuries of the head, by inducing pressure on the brain and coma. The blood that is extravasated usually coagulates into a firm granular clot. There can be no doubt, however, that extravasation of blood into the membranes of the brain frequently occurs without being attended by fatal consequences. The blood that is so extravasated may undergo various changes: 1. The extravasated blood may be absorbed entirely; 2. The serous portion, and a great part of the colouring matter, may be removed, leaving a fibrinous

buff-coloured layer, which may occasionally become organized. This occurs only in arachnoid hæmorrhage. Such layers are sometimes double, and then, forming a flattened cyst, the cavity of which is merely moistened by a little fluid, are occasionally found unexpectedly in the arachnoid cavity many years after the injury which gave rise to the extravasation; 3. The exterior of the clot may become consolidated, whilst the interior contains fluid and disintegrated blood. This occurs in the cerebral substance, and the cysts thus formed are permanent.

Symptoms.—The only definite symptom of extravasation of blood is gradually increasing insensibility, ending in coma within twenty-four hours of the injury. It is, however, a matter of the greatest practical importance to determine, if possible, whether the hæmorrhage is taking place between the dura mater and the bone, or whether it arises from a laceration of the brain-substance.

In the first variety there are, in typical cases, three distinct stages; viz., concussion, a return and some continuance of consciousness, and then coma gradually supervening. The patient is concussed or stunned as usual, after the receipt of a blow on the head; from this he quickly rallies, and then symptoms of compression set in, and gradually increase in intensity. He becomes drowsy and dull, with a slow and labouring pulse, dilated and sluggish pupils, and a tendency to slow respiration. As the compression increases, complete stupor at length comes on, with stertor in breathing, and there is either general paralysis, or hemiplegia of the side opposite to the seat of injury. More commonly there is first, hemiplegia of the side opposite to the seat of injury, speedily followed by complete general paralysis. Convulsions may occur during the time the hæmorrhage is taking place, but are not common.

When the symptoms run this regular course, it is probable that the extravasation results from injury of one of the meningeal arteries or large venous sinuses; and that there is no laceration of the substance of this organ, for it may safely be assumed that if the patient recovers consciousness after the accident, he cannot have such a degree of tearing and bruising of the cerebral substance as to lead to sufficient escape of blood to cause compression of the brain. This form may be termed the **Meningeal Extravasation**; it most commonly arises from rupture of the anterior branch of the middle meningeal artery, which, from its situation in a deep groove in the parietal bone, is peculiarly apt to be torn in injuries of the side of the skull.

When this artery is the source of the blood, the clot extends deeply down into the base of the skull; and Hutchinson pointed out that in this way it may exert powerful pressure on the cavernous sinus leading to fulness of the vessels, with protrusion of one eyeball and wide dilatation of the pupil. This occurs on the same side as the extravasation, and thus we may get hemiplegia of the opposite side, while the more dilated pupil is on the same side as the injury. In cases complicated with a fissured fracture, some of the blood forces its way through the fissure, and thus may cause marked fulness of the temporal fossa on the affected side, clearly to be seen when the head has been shaved. A few years ago a man was admitted into University College Hospital who had fallen from the driving seat of a van. He got up again and took the reins, but feeling sick and giddy he left the box and lay down in the van, while his companion undertook to drive. About one hour afterwards he was found comatose. His head was shaved on admission, and on careful

inspection a distinct fulness was noticed in the right temporal fossa, and on the parietal eminence of the same side was a bruise. He was trephined in the line of the artery and a large clot found and removed, but the brain failed to expand, and he died a few hours afterwards. In another case, which occurred shortly afterwards, the patient fell eight or nine feet, and a quarter of an hour afterwards she came to the hospital. She was conscious, and related how the accident happened. There was a wound on the right side of the head, near the parietal eminence. She rapidly became unconscious, and two hours after the fall she was apparently dying. At this time the right eyeball was protruded, and the pupil widely dilated ; the left was dilated, but less so than the right. She was trephined on the right side, and a large clot found and removed ; the symptoms of compression were relieved, but she died eighteen hours after the accident. In both cases the brain was uninjured.

In some of these cases the respiration often becomes greatly embarrassed, and this must always be looked upon as a grave symptom, indicating the necessity for operative treatment.

The **mechanism** of meningeal extravasation has given rise to much discussion, and the following remarks of Sir Charles Bell (" Surgical Observations," London, 1816) are well worthy of attention. " It is extraordinary that any one who has ever raised the skull-cap in dissection, and felt the strength of the universal adhesions of the dura mater to the lower surface of the bone, could for an instant believe that the *arteria meningea media* has power of throwing out its blood to the effect of tearing up these adhesions from the entire half of the cranium ! " He then describes the following experiment to show that the dura mater is first of all separated from the skull, and that the extravasation is consequent on that separation. " Strike the skull of the subject with a heavy mallet ; on dissecting, you find the dura mater to be shaken from the skull at the part struck. Repeat the experiment on another subject, and inject the head minutely with size-injection, and you will find a *clot* of the injection lying betwixt the skull and dura mater at the part struck, and having an exact resemblance to the coagulum found after violent blows on the head. I imagine this is conclusive " (pp. 466—67). It is possible also that the alterations in form of the skull which accompany blows causing fracture (*vide* p. 718) may tend to loosen the attachment of the dura mater. That the meningeal artery does, however, pour out blood with sufficient force to strip the dura mater further from the bone, when it is once loosened, can hardly be doubted, as it is difficult to conceive that that membrane can be shaken from the base of the skull by a blow on the parietal eminence ; and yet meningeal extravasation often extends as far as the cavernous sinus. It must not be forgotten that when once a cavity is formed, the blood forced in acts somewhat on the principle of the hydraulic press. Taking the pressure in the artery to be about two pounds to the square inch, when four square inches of dura mater are separated we have a force of eight pounds pressing against it ; when it is separated for three inches in each direction the pressure equals eighteen pounds. To resist this we have only the adhesion of the dura mater and the blood-pressure in the capillaries of the brain substance. It is not surprising, therefore, that the force exerted by the escaping blood produces such marked effects.

The extravasation of blood dependent on laceration of a portion of the brain may be termed **Cerebral Extravasation.** It is far more common than

the meningeal form; in it the patient never recovers his consciousness after having been stunned, the symptoms of concussion speedily passing into those of compression. In these cases the paralysis is commonly incomplete, often hemiplegic, and is associated with twitching of the limbs or convulsive movements of the body generally, and much restlessness with incoherent muttering: the pupils are sometimes contracted, sometimes dilated, and occasionally squinting is observed. It is especially when there are convulsions that the pupils are observed to be in different conditions; and I have most frequently noticed the pupil dilated on the side that is most convulsed.

Diagnosis.—The diagnosis of these two forms of extravasation from one another is important, as it is in the meningeal only that any operative procedure can be successfully undertaken; and it may usually be effected readily by attention to the symptoms just detailed. When the two forms occur together the diagnosis is, frequently, almost if not quite impossible.

The diagnosis between the compression from *extravasation* and that from *depressed bone* or *inflammatory effusions within the skull* is easily made. In the case of depressed fracture, the symptoms of compression continue uninterruptedly from the very first, and proper examination of the skull will always lead to the detection of the injured bone. When inflammatory effusions, whether of pus, lymph, or serum, exercise undue pressure upon the brain, the signs of compression come on at a later period and are preceded by symptoms of cerebral inflammation, accompanied by a good deal of pyrexia, by quick pulse and hot skin. The character of the scalp-wound likewise, and the separation of the pericranium when pus is formed, enable us to distinguish this condition from that in which the pressure is the result of extravasated blood.

From *apoplexy*, the diagnosis is not always easily made, more particularly when there is no evidence that the head has been injured. I could give numerous instances of this. The following will suffice. A man was brought to University College Hospital in a state of profound coma, in which condition he had been found lying in the street. There was no evidence of injury about the head, beyond a bruise, which had probably been received when he fell. The case, which was supposed to be one of apoplexy, and treated accordingly, proved fatal in a few hours. On examination after death the skull was found fractured, but not depressed. On the opposite side to the bruise and fracture, a coagulum, weighing nearly four ounces and compressing the brain, lay between the dura mater and bone. In such a case, it is evident that the history can alone afford a clue to its true nature. Even when the head has been injured, it is not always easy. A man was admitted under my care, comatose. A fortnight previously he had been struck on the left side of the head behind the ear. He was stunned, bled freely from the left ear, but then recovered tolerably, and went about his avocations as usual until the day before his admission, when he became suddenly comatose. There were stertor, quick pulse, and some heat of head; the right pupil was natural, the left contracted. He was treated antiphlogistically, but died on the third day. On examination, a fracture on the left side of the skull was found, extending into the left internal meatus; on the right side of the head, immediately opposite the fracture and the seat of injury, there was a large coagulum in the cavity of the arachnoid, with some sero-plastic exudation about it. Here was a meningeal extravasation, the result of *contrecoup*, existing without symptoms for

fourteen days, and then proving rather suddenly fatal by inflammation. A woman, whilst walking with her sister, fell in the street. She was taken up insensible ; thought to have a fit ; became comatose, hemiplegic on the right side, and died the next day. After death the left parietal bone was found fractured, and a clot that weighed five and a half ounces was found lying over the ruptured middle meningeal artery on the dura mater. Or the injury may be so slight as barely to attract attention : a lady going into the opera stumbled as she went down some stairs, and struck the side of her head against the wall. She felt giddy and confused, returned home, went to bed, was found comatose the next day. I was sent for, but before I could trephine her she had died. On examination, a four-ounce-clot was found on the dura mater, under a ruptured meningeal artery, but without fracture. I have seen the same in a boy, who, running down stairs to his dinner, struck his head against the opposite wall ; he ate his dinner, vomited, became drowsy, and died. A large clot was found on the dura mater at the part struck. In neither of these cases was there any external bruise or other sign of injury.

The insensibility of *drunkenness* may usually be distinguished from the coma resulting from injuries of the head, by the absence of local mischief, by the smell of the breath, and by the face of the drunkard being flushed and turgid, and not pale as in a person who is suffering from the effects of a severe injury. When a drunken person has met with an injury of the head and is insensible, he should always be carefully watched, however slight the injury may appear to be, until sufficient time has elapsed for him to recover from his drunken fit, as it is impossible to say whether the stupor be the result of intoxication, or of mischief within the skull ; and I have known cases to be sent away from hospitals as drunk, when in reality the stupor was occasioned by the pressure of depressed bone upon the brain.

In the stupor from *poisoning by opium*, the condition of the pupils, which are contracted to the size of a pin's point, instead of being widely dilated as in coma from cerebral compression, will enable the Surgeon to make the diagnosis.

The **Treatment** of extravasation of blood may be conducted on two principles—either by means of general and local antiphlogistic measures, having for their object the arrest of further hæmorrhage, the promotion of absorption, and the subdual of inflammation ; or else by the application of the trephine, with the view of allowing the escape of the effused blood. The place adopted should I think, have reference to the character of the symptoms.

Although **Trephining** in cases of extravasation was formerly much in vogue, it is seldom had recourse to by modern Surgeons, and is proper only in the meningeal form of extravasation. When the symptoms indicate *cerebral* extravasation, trephining can be of little service, and we must be content with general measures ; but when the extravasation seems to be *meningeal*, then an attempt may be successfully made to evacuate the extravasated blood.

The most serious difficulty in determining on the mode of treatment does not consist so much in ascertaining that blood has been effused within the skull, as in the difficulty of diagnosing that it is so seated between the dura mater and the bone as to admit of removal ; not being effused at the base, nor so widely coagulated over the surface of the brain as to be unable to escape through the aperture that may be made. The likelihood of the co-existence of fracture of the base of the skull and of laceration of the brain, giving rise to the cerebral form of extravasation, must also be taken into account. For

these various reasons, Surgeons now very wisely content themselves, in the great majority of cases of extravasation, with the employment of antiphlogistic treatment, on the principles already stated. The head should be shaved, the ice-bladder applied, the patient bled, purged, and kept at perfect rest.

If it can, however, be ascertained without doubt that the extravasation is not only meningeal, but that it is so situated that the blood may be removed through the trephine-aperture, and if there be no other serious injury to the brain or skull, trephining should at once be performed. And doubtless cases occasionally occur in which, from the situation of the blow, and perhaps the presence of a capillary fissure over the course of the middle meningeal artery, the gradual supervention of signs of compression after an interval of consciousness, and the occurrence of hemiplegia on the side opposite to that which has been struck, the Surgeon is warranted in making an aperture in the skull at the seat of injury, in order to remove the blood that has been poured out, and to arrest its further effusion. But the instances in which this assemblage of symptoms exists, with sufficient precision to justify an operation, are excessively rare. Out of many hundred cases of serious and fatal injury of the head that were admitted into University College Hospital during the time I had charge of wards in that institution, in four cases only, I believe, was it found advisable to have recourse to trephining for the removal of extravasated blood. In three of these cases death speedily ensued, the coma being unrelieved by the operation. In the fourth case, recovery took place. The successful case to which I refer was that of a man admitted comatose, three days after receiving an injury of the head by a fall from a cab. There were no serious symptoms for some hours after the accident ; but then stupor gradually came on, amounting at last to complete coma. On examination, a bruise of the scalp was found on the left temple : through this I made an incision, and, finding a starred fracture over the sinus of the middle meningeal artery, trephined the bone, when a large coagulum was found lying upon the dura mater, and, on removing this, fluid arterial blood freely welled up. The coma was relieved, and the patient made a good recovery.

During the last eleven years, over which period the reports of University College Hospital extend, four cases have been trephined for meningeal hæmorrhage ; three by M. Beck, all of which terminated fatally, and one by Godlee, which was successful. In this case the bleeding artery was seen and secured by a ligature.

In fact, in all cases in which there has been a fall or blow on the head, followed by the symptoms above described ending in coma, even though there may be no external marks of violence, the Surgeon should cut down on the skull, and examine it for fracture—to trephine if necessary. If there be no injury to the bone, no evil can result in such a case from the simple incision in the scalp. If there be fracture, the incision is the only means of diagnosis, and the first step towards saving life. But it must be borne in mind that, however clear the signs, extravasation may not be met with where the Surgeon expects to find it. In these circumstances, it is better not to prosecute the search by making fresh trephine-apertures. In no case would a prudent Surgeon trephine over the course of the middle meningeal artery in the absence of local symptoms, on the chance of finding the blood there, as has been recommended by some of the older Surgeons. The middle meningeal artery may be wounded at any part of its course within the skull, but it is

very rare for the main trunk to be ruptured; almost invariably it is the anterior branch that suffers. This branch is first directed forwards across the great wing of the sphenoid to near the tip of the small wing; here it takes a sharp curve backwards, and often enters a canal in the bone; from this point it is directed backwards and upwards in the groove which crosses the anterior inferior angle of the parietal bone. Its course may be found externally by the following rule:—Draw a straight line backwards from the external angular process of the frontal bone; take point at any distance between one inch and two and a half inches from the angular process in this line and draw a vertical line through it from the zygoma; measure a corresponding distance up this line, and the point so found will be over the artery. If the distance taken be under one inch and a half, the artery will very frequently be found in a canal in the bone; beyond this it is usually in a groove. Accuracy is of importance only when a fissured fracture is found, as the centre of the crown of trephine should, if possible, be at the point at which the fissure crosses the line of the artery. In other cases a very sufficient and practical guide is to put the pin of the trephine two and a half inches vertically above the condyle of the lower jaw. Having found the line of the artery, a T-shaped incision should be made with the horizontal limb parallel to the zygoma, the middle of the vertical incision being opposite the point at which the artery is supposed to lie. The incision divides the scalp and the temporal aponeurosis and muscle. In doing this a large branch of the superficial and one or both deep temporal arteries will be cut and require ligature; the bone is then cleaned, saving the periosteum, and the crown of a large trephine applied, with the pin of the instrument over the spot where the vessel is supposed to lie. If the diagnosis have been correct, as soon as the circle of bone is removed a dark solid clot pushes its way up into the opening. As a rule, however, it is too solid to come out without the use of a scoop, and for this purpose a small lithotomy scoop may be used. The Surgeon, having now trephined and removed the blood clot, is confronted with what is truly the greatest difficulty of the case. The artery in the majority of cases follows the dura mater, for it is only if it be in a canal in the bone that it remains superficial. If the brain expands immediately upon the pressure being removed, the injured artery may come into view; if not, all that is seen is a profuse flow of blood pouring out of the opening in the skull, and apparently in some cases threatening to be almost immediately fatal. Under these circumstances all that can be done is to raise the patient into a sitting position, to compress the carotid, and to apply ice to the side of the head and neck. Under this treatment the bleeding usually ceases rapidly and does not recur. If the actual wounded spot can be seen, a fine catgut or carbolized silk-ligature must be passed round it with a sharp needle. If the artery lie in a canal, and its torn end can be seen bleeding where the trephine has cut through it, the hæmorrhage may be arrested by inserting a small plug or by touching it with the cautery.

In some cases the hæmorrhage is due to the tearing of a large number of small vessels, and not to the wound of any special branch. Thus, in one of the fatal cases in University College Hospital, a child, aged seven, the most careful examination failed to detect any wounded artery. The hæmorrhage was in this case situated behind the region of the large branches of the meningeal artery.

In very exceptional cases it may be justifiable to remove more bone to get at the bleeding point, but this can be only when the situation of the wound can either be seen or can be recognized by the finger.

The operation should, wherever possible, be performed with most careful antiseptic precautions.

EPILEPSY FOLLOWING HEAD INJURIES.

Head injuries are occasionally followed by traumatic **Epilepsy**. The occasioning cause may be of various kinds. This may arise, 1st, from a depressed and neuralgic cicatrix on the scalp—the starting point of reflex convulsions; 2nd, from chronic osteitis of the part of the skull struck, giving rise to thickening and induration of the bone; 3rd, from depression of bone or the formation of osseous stalactites pressing upon the dura mater or brain; 4th, from chronic thickening of the dura mater; and, 5th, from obscure structural lesions of the brain-substance.

In the *Treatment* of traumatic epilepsy arising from these various causes, operative interference may as a last resource, and after failure of all the ordinary constitutional means, be had recourse to. The practice of trephining in these cases is a very ancient one. The older Surgeons often employed it. Cline cured a patient by it whose epilepsy was found to be occasioned by a stalactiform osseous projection from the inner table, and whose last fit was on the operating table before the elevation of the disc of affected bone. But the practice fell into disuse until recently revived by Lucas-Championière, West, and others. It is evident that, when there is distinct evidence of injury to the bone, an operation may offer a fair prospect of relief or of cure by the removal of the depressed, thickened, or out-growing osseous structure; and in such cases, and in such only, it is right to do it. The trephine should be applied at the seat of injury. When a painful cicatrix in the scalp alone seems to be the starting point of that reflex irritation which developes the epileptic attack, we may follow Bryant's advice, and dissect it up without trephining the subjacent bone.

OPERATION OF TREPHINING.

Before concluding the subject of injuries of the head, it is necessary to say a few words on the operation of **Trephining**, which, though far less commonly employed in the present day than heretofore, is one of sufficient frequency, as well as of great importance from the serious nature of the cases that require it.

The operation of trephining may be required for one of the six following conditions, viz. :—

1. Simple depressed fracture of the cranium with symptoms of compression.
2. Compound depressed fracture of the cranium, with or without symptoms of compression.
3. Punctured or incised fracture of the cranium.
4. Extravasation of blood between the cranium and dura mater from rupture of the middle meningeal artery.
5. Intracranial abscess.
6. For the removal of a bullet lodged within the cranium.
7. For the cure of traumatic epilepsy.

The trephine may thus be applied to the skull for the fulfilment of one of two principles—either with the view of preventing inflammation and its con-

sequences, or for the purpose of removing some cause of compression. The only case in which *preventive* trephining is practised by modern Surgeons is that of the punctured or starred fracture of the skull, without stupor ; in all other instances in which it is called for, the object of its application is the *removal* of a cause of compression or of irritation of the brain, such as a depressed portion of bone, foreign bodies either fixed in the skull or lying close under it, or pus or blood extravasated within the cranial cavity.

The trephine should have a well-tempered crown, serrated half-way up its exterior ; the teeth should be short and broad; the centre-pin must not project more than about one-sixteenth of an inch, and care must be taken that the screw which fixes it is in good working order. The other instruments

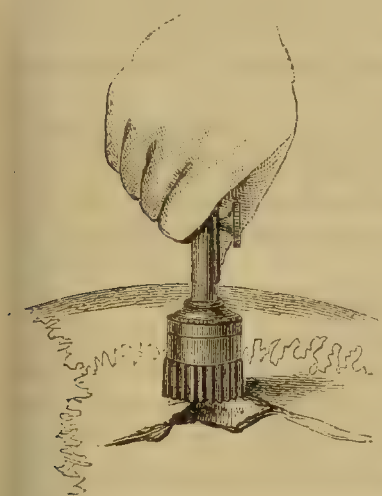


Fig. 326.—Application of Trephine.

Fig. 327.—Trephine-cut at edge of fracture.

required are a Hey's saw, an elevator that will not readily snap, a pair of strong dissecting forceps, and a quill cut to a rather long blunt point.

The operation itself should be conducted in the following way. The head having been shaved, and the portion of the skull to which the trephine is to be applied having been freely exposed by means of a crucial or T-shaped incision, or by the enlargement of any wound that may exist, the periosteum is to be carefully raised with a periosteal elevator from the whole area to be removed. The trephine, with the centre-pin protruded and well screwed down, is now to be firmly applied until its teeth touch the skull (Fig. 326) ; it is then worked with rather a sharp, light, and quick movement, the pressure being exercised as the hand is carried from left to right. The centre-pin must be withdrawn as soon as a good groove is formed by the crown, lest it perforate the skull first and injure the dura mater. In this way the outer table of the skull is quickly divided, and the diploë cut into (Fig. 327) ; the detritus which now rises by the crown of the trephine is soft and bloody, instead of being dry, as it is whilst the outer table is being sawn. As the instrument approaches the dura mater, the sawing must be conducted more warily, and must every now and then be interrupted, in order that the Surgeon may examine with the quill, or with the flat end of a probe, the depth that has been obtained, care being taken that this is uniform throughout the circle. The Surgeon now makes each turn very lightly, and now and then tries with a slight to-and-fro movement whether the circle of bone is

loose. So soon as it is, he withdraws it in the crown of the trephine, or raises the bone by means of the elevator. In this operation the dura mater must not be wounded; if it be injured, fatal consequences may ensue. The objects for which the trephining has been had recourse to must now be carried out, depressed bone being elevated or removed, and pus or blood evacuated. The scalp should then be laid down again, and a few sutures applied, leaving good space for drainage.

The operation should, whenever possible, be performed with all antiseptic precautions. The dressing may be either carbolic gauze, or dry iodoform-, or salicylic-wool. Of these, the gauze is preferable, as an ice-cap can be applied over it if necessary. If no antiseptic material be at hand, the Surgeon must avoid the use of water; he may wipe away the blood with the dry lint, and apply a dry dressing afterwards. By this means he will give the patient the best chance of escaping putrefaction of the discharges and septic meningitis in those cases in which the dura mater is wounded.

There are certain parts of the skull—over the venous sinuses, for instance, and near the base—to which no prudent Surgeon would apply the instrument. If it were ever thought necessary to trephine at the frontal sinuses, the outer table must first be removed with a large crown, and the inner table sawn out with a smaller one.

The escape of cerebro-spinal fluid through a trephine aperture is a remarkable occurrence. In one such case recorded by Clement Lucas, the cerebro-spinal fluid began to escape the day after the operation. The patient, however, so far recovered as to be on the point of leaving the Hospital, when erysipelas set in, and he died of acute meningitis. After death, the track of damaged brain was found leading to the ventricle from which the fluid had escaped through the scalp. This case confirms the important observation made by Clement Lucas, that where cerebro-spinal fluid escapes through the calvaria, the ventricular cavity of the brain has always been opened.

After the operation, careful attention must be paid to antiphlogistic measures of a preventive and curative kind, the great direct danger to be apprehended being inflammation of the brain and its membranes. In some cases, also, there is reason to believe that suppurative phlebitis of the sinuses and veins of the diploë has been the cause of death.

Before the use of Antiseptics the operation of trephining was by no means favourable in its results. Of 45 cases reported by Lente, as occurring at the New York Hospital (in which, however, there is no distinction made between the application of the trephine proper and of various instruments, such as the elevator, Hey's saw, &c., belonging to a trephining case), only 11, or about one-fourth, recovered. Of 17 cases in which the trephine proper was used at University College Hospital, by Cooper, Liston, and myself, 6 patients recovered, 1 other died of injury of the spine unconnected with the operation, and the remaining 10 died from various causes. In the late American war, the results have been more satisfactory than the previous experience of Army Surgeons would have led us to hope. Of 107 cases of trephining, 47 recovered; and of 114 cases where fragments of bones were removed by the forceps and elevator, without the use of the trephine, 53 recovered. The Parisian Surgeons have not been very successful. Nélaton says that all the cases of injury of the head, 16 in number, in which the trephine had been used in the Parisian hospitals during fifteen years, terminated fatally.

As the older Surgeons never published statistics, we have no authentic figures to show us the mortality that followed trephining in former times, when it was undertaken very recklessly, as we should now think ; but it seems improbable that an operation so lightly undertaken could have been very fatal. The good results would seem to have been due to two causes—first, a large number of the cases in which it was done were uncomplicated by serious brain-injury or -disease; and secondly, the drainage after the operation must have been very perfect, as the piece of scalp corresponding to the bone removed was also taken away, the wound being left to heal by granulation.

The introduction of antiseptic surgery has greatly reduced the mortality, especially in cases in which the dura mater is wounded. Kramer gives the following results obtained from published cases and the reports of hospitals in which the antiseptic system has been adopted. Of 25 cases in which primary trephining was performed for compound fracture, 21 healed by first intention, 2 after suppuration, and 2 died, 1 of circumscribed meningitis, and 1 of meningo-encephalitis. In 6 cases of secondary trephining, 3 healed by first intention, 2 by second intention, and 1 died with hernia cerebri. In 22 cases in which the skull was opened, through a previously sound scalp, for tumours, epilepsy, old depressed fractures, &c., 21 healed without fever, 13 by first intention, and none died.

In considering the mortality after trephining, it must be remembered that the unfavourable result, which so frequently follows, is not always to be attributed to the operation itself. In a large proportion of fatal cases death results rather from the injury sustained by the brain, from pressure of extravasated blood, or from inflammatory mischief round a laceration of the cerebral substance, than from the operation ; and as the cases to which modern Surgeons now restrict the use of the trephine would necessarily prove fatal if left to themselves, it is but right to give the patient the chance of escaping with life, however slender that chance may be.

CHAPTER XXV.

INJURIES OF THE SPINE.

Injuries of the spine, like those of the head, derive their importance mainly from the lesions of the inclosed nervous structures by which they are accompanied. Speaking clinically, by "the spine" is meant not the vertebral column only—that is merely its skeleton—but the whole of those structures which in the living body connect together, or are included within the various bones of which that column is composed. These structures are of the most diversified character; they include muscles, tendons, ligaments, cartilage, fibro-cartilage, synovial membrane as bonds of union. As included structures we find the spinal cord, its membranes and blood-vessels, the roots of the spinal nerves, the nerves themselves, ganglia and branches of the sympathetic. Clinically these must all be considered as constituents of the spine—as forming parts, indeed, of one organ. In an injury of the spine, whether it be direct or indirect, all these structures are liable to be implicated to a greater or lesser extent. In a severe injury such as a fracture, it is evident that the lesion is not confined to the bones, but implicates more or less extensively all the external structures that enter into the conformation of the spine, as well as the included structures—the cord and its membranes, and the spinal nerves in their exit from the canal. So also in less severe and direct injury, as in a concussion, the effect is not limited to one anatomical constituent only, whether that be the bones or the cord, but implicates more or less severely one and all of the structures that enter into the formation of the spine, or that are included in its canal. The degree to which each suffers will necessarily vary greatly according to the force, the character, and the direction of the violence, but all are liable to the effects of the injury. It is of the utmost importance to bear this fact in mind, in making the diagnosis and considering the possible after-consequences of these injuries. In some cases the ligaments and muscles, in others the bones, in others again the spinal nerves, or the cord itself, will appear to be the part that has chiefly suffered; but in no instance will it be found that the damage has been confined to one structure, to the exclusion of all the rest.

By **Concussion of the Spine**, then, I mean the case in which by a blow upon the back, by a severe shake of the body, or by a fall from a height on to the buttocks or feet, the various anatomical constituents of the spine have been severely jarred, shaken or strained.

When the injury is confined mainly to the motor apparatus of the spine, it is apt to be followed by much pain on movement of the body, especially in such directions as to stretch the injured parts. These pains lead to instinctive fixity of the injured parts, and the painful rigidity so resulting is often of a most persistent and intractable nature.

In other cases, the nervous structures mainly are injured. When the spinal nerves are stretched or their sensory roots damaged, neuralgic pains of a most

intense character, often occasioning wide-spread cutaneous hyperæsthesia, will develope. If, again, the cord is the part that has mainly, or in conjunction with the others, been the seat of injury, symptoms that may more distinctly be referred to **Concussion of the Spinal Cord** will result. But these, it must be remembered, will always be found to be more or less complicated with or masked by the damage done to the locomotor and the other nervous constituents of the spine.

What has here been said with regard to the effects of primary lesion of the spine is equally true with respect to the secondary consequences of such injuries. An injury inflicted on the ligamentous structures of the spine may readily develope local inflammatory conditions, that eventually extend by continuity of structure to the meninges of the cord. A lesion of a spinal nerve may give rise to a neuritis, which assuming an ascending and progressive character, will lead to permanent and organic disease of one of the lateral segments of the cord. And so an injury of the cord itself at one part may after a time lead to organic changes at a distant and higher point.

The SPINAL CORD is subject to *Concussion*, *Compression*, and *Inflammation*, as the result of external violence ; and any of these conditions may occur without injury to the osseous and ligamentous structures investing it, although, in the majority of cases, they are directly occasioned by fracture or dislocation of the vertebræ. The cord may also be *partially or completely divided* by cutting instruments, gun-shot wounds, or broken vertebræ.

CONCUSSION OF THE SPINAL CORD.*

It is by no means easy to give a clear and comprehensive definition of the term, **Concussion of the Spinal Cord.** The term is clinical rather than pathological. It is generally adopted by Surgeons to indicate a certain state of the cord occasioned by external violence ; a state that is independent of, and usually, but not necessarily, uncomplicated with, any obvious mechanical lesion of the vertebral column, such as fracture or dislocation ; a condition that is supposed to depend upon a shake or jar received by the cord, by which its intimate structure is more or less deranged, by which its functions are greatly disturbed, and in which various symptoms indicative of loss or modification of innervation are immediately or remotely induced.

It appears that Surgeons and writers on diseases of the nervous system have included four distinct pathological conditions under this one term, *concussion of the spinal cord ;* viz., 1. A jar or shake of the cord, disordering, to a greater or less degree, its functions, without any lesion perceptible to the unaided eye ; 2. Compression of the cord from extravasated blood ; 3. Compression of the cord from inflammatory exudations within the spinal canal, whether of serum, lymph, or pus ; and, 4. Chronic alterations of the structure of the cord itself, as the result of impairment of nutrition consequent on the occurrence of one or other of the preceding pathological states, but chiefly of the third. These various conditions differ remarkably from one another in symptoms and effects, and have only this in common—that they are not dependent upon an obvious external injury of the spine itself; in which respect they differ from the

* I would refer the reader to my work on "Concussion of the Spine, Nervous Shock, and other Obscure Injuries of the Nervous System," London, 1882, for a more complete exposition of this subject than can be given here.

laceration or compression of the cord by fracture with displacement or dislocation of a vertebra.

Symptoms indicative of concussion of the spinal cord frequently occur, in consequence of injuries sustained in railway-collisions, and have been very forcibly brought under the observation of Surgeons in consequence of their having been the fertile sources of litigation ; actions for damages for injuries alleged to have been sustained in railway-collisions having become of such frequent occurrence as now to constitute a very important branch of medico-legal inquiry. The symptoms that arise from these accidents have been very variously interpreted. Some practitioners have ignored them entirely, believing that they exist only in the imagination of the patient ; or, while admitting their existence, have attributed them to other conditions of the nervous system which could not have arisen from the alleged accident. And when their connection with, and dependence upon, an injury have been incontestably proved, no little discrepancy of opinion has arisen as to the ultimate result of the case, the permanence of the symptoms, and the curability of the patient. I cannot too strongly urge the fact that there is in reality nothing special in the symptoms of concussion of the spine produced by railway-collisions, except the severity of the accident by which the concussion is occasioned, and that it is consequently a mistake to look on a certain class of symptoms as special and peculiar to railway-accidents. Injuries received on railways may differ in their severity, but do not differ in their nature, from injuries received in the other accidents of civil life. There is no more real difference between that concussion of the spine which results from a railway-collision and that which is the consequence of a fall from a horse or a scaffold, than there is between a compound and comminuted fracture of the leg occasioned by the grinding of a railway-carriage over the limb and that resulting from the passage of the wheel of a cart across it. In either case, the injury arising from the railway-accident will be essentially of the same nature as that which is otherwise occasioned ; but it will probably be infinitely more severe and destructive in its effects, owing to the greater degree of violence that occasions it.

Concussion of the spinal cord may be produced either by *direct violence*, as by severe blows or falls on the back, giving rise to local pain and signs of contusion, or by slight blows : or by *indirect violence*, as when a person meets with a fall, or general concussion of the body, without any evidence of a blow having been inflicted on the spine itself ; or by *twists and sprains*, or wrenches, of the vertebral column.

Concussion from Direct Violence.—Concussion or commotion of the spinal cord, as a consequence of severe and direct blows upon the back, has long been recognized and described by those writers who have occupied themselves with the effects of injuries to this part of the body.

The **Primary Symptoms** of concussion of the cord immediately and directly produced by a severe blow upon the spine will necessarily vary in severity and extent according to the situation of the injury, the force with which it has been inflicted, and the amount of organic lesion that the delicate structure of the cord has sustained from the shock or jar to which it has been subjected. A severe blow upon the **Upper Cervical Region** may produce instantaneous death ; a less severe blow may produce paralysis of one or of all the limbs, with every possible modification of combined or disassociated

loss of motor power and of sensation, of hyperæsthesia and of anæsthesia; or it may give rise to various phenomena, dependent on irritation of the large nerves that take their origin from the medulla oblongata. Thus, when the *vagus nerve* is affected, a sense of suffocation, with irregular action of the heart, may be experienced, or severe vomiting may be established, and may continue for months. Sometimes the *spinal accessory nerve* is irritated, and the trapezius or the sterno-mostoid muscle thrown into a more or less permanent spasmodic state. From injury about the origin of the *phrenic nerve*, hiccup and a peculiar sense of constriction round the body, as if the patient were girt by an iron band, may be established. In other cases, again, the diaphragm becomes partially paralysed, it does not descend properly in inspiration, hence dyspnœa, often to a very serious extent, is induced.

When the **Lower Part of the Cervical Spine** has been struck so as to concuss the cord, I have known paralysis of one or both arms induced, without any paralytic symptoms of the trunk or legs. In these cases the paralysis may go off entirely; or it may disappear in one arm and continue in the other; or one nerve only may continue to be affected—such as the *circumflex*, the *musculo-spiral*, or the *ulnar*. There may be complete paralysis of sensation and of motion in any one of these nerves; or motor power may be lost, whilst sensation is normal; or, more commonly, where the sensibility continues, it is exalted, and we may find loss of motor power with hyperæsthesia. These modifications of innervation may be confined to one nerve, as the musculo-spiral, when there will be loss of motor power in the extensors and supinators of the forearm and hand, with loss of sensation or with hyperæsthesia of the part of the hand supplied by the *radial* nerve. In other cases we find motor paralysis of the circumflex or musculo-spiral nerve, and hyperæsthesia of the ulnar. In these respects there is every possible variety.

A severe blow inflicted on the **Dorsal** or the **Lumbar Region** may induce more or less complete paraplegia. In some cases the paralysis of the lower limbs has been complete and instantaneous; and has affected both sensation and motion, with loss of power over the sphincters. In other cases there has been only paralysis of motion, sensation continuing perfect or being in excess. The reverse has been met with, but less frequently and less completely; there being loss of sensation, and impairment, though not complete loss, of power over motion. One leg is frequently more severely affected than the other. Or the two legs may be unequally affected as to sensation and motion; both sensation and motion being impaired, but in varying degrees in the two limbs. There may be complete loss of power over the sphincters both of the bladder and anus, with incontinence or retention of urine and fæces; or the loss of power may be confined to the bladder, which is especially the case when there is paralysis of motion rather than of sensation in the lower limbs. The state of the urine will vary. If there be no retention, it will continue acid. When there is retention, the urine usually becomes alkaline, but sometimes, even when there is complete retention, it remains strongly acid; and Ollivier noted the very remarkable circumstance in one case of retention, that there was an enormous formation of uric acid, so that the catheter became loaded with it. Priapism does not occur in concussion, while it does so often in cases of laceration and irritation of the cord.

The Temperature of the body generally falls below the normal standard, often very markedly so: the extremities and the mouth being especially cold.

When tested by the thermometer, in the mouth or axilla, the temperature will often be found to be from four or six degrees below the normal standard; but when the thermometer, which perhaps marked only 90° F. in the axilla, is placed in the rectum, it will be found to rise above normal to 99° or 100° F. This is very important as shewing that the whole body is not uniformly of a lower temperature than normal. It points rather to a disturbance of the vaso-motor action of the sympathetic nerve than to any direct influence exerted by the spinal cord, and may be connected with that condition of abdominal congestion which is so common a sequence of these injuries.

The **Secondary Symptoms** of severe concussion of the spine are usually those of developing inflammation in the meninges and in the cord itself. They consist of *pain* in some part or parts of the spine, greatly increased by pressure and motion, and *rigidity* of the vertebral column, the patient moving it as a whole. The pain is greatly increased by all movements, but especially by those of rotation. It frequently extends as a line down the limbs or as a circle round the body, giving the sensation of a cord tied tightly.

If the case go on to the development of acute inflammation in the membranes of the cord, *spasms* of a serious character come on; at first, usually of the nature of trismus; then general spasms of the body and limbs, mostly followed by speedy death from the exhaustion produced by their repetition.

If the inflammation become chronic or subacute, permanent *alterations in the structure of the cord* will ensue, leading to incurable paralytic affections, usually confined to the lower extremities, and associated with great and deep-seated derangement of the general health.

White softening of the cord, unassociated with signs of inflammation of it or its membranes, may be the result of a blow on the back. In this condition paralysis of sensation or motion, often accompanied by peculiar rigidity of the muscles, may come on, and ultimately advance to general paralysis.

Causes of Death.—Concussion of the spinal cord from a severe and direct blow upon the back may prove fatal at very different periods, depending partly on the situation of the blow, and in a great measure on the lesions to which it has given rise. Sudden and fatal paralysis has often occurred, without leaving after death any lesion of the cord that could be assigned as the cause of death. Abercrombie says, "Concussion of the cord may be speedily fatal without producing any morbid appearance that can be detected on dissection." And he refers to a case related by Boyer, and four recorded by Frank, in confirmation of this remark.

In other cases, the fatal result may be occasioned by direct and demonstrable injury of the spine or cord. There appear to be four forms of lesion that will lead to death in spinal concussion from direct severe violence.

1. Hæmorrhage within the spinal canal:—*a.* Between the vertebræ and the dura mater; *b.* Between the membranes and the cord: *c.* In both situations. In these respects, intravertebral extravasations resemble closely those which occur as the result of injury within the cranium.

2. Laceration of the pia mater and hernia of the cord.

3. Extravasation into the substance of the cord.

4. Inflammation, and, perhaps, suppuration of the meninges, with softening and disintegration of the substance of the cord. This disintegration is, doubtless, of an acute and probably inflammatory character.

Concussion of the spinal cord from a direct and severe injury of the back may terminate also in complete recovery after a longer or shorter time, or in incomplete recovery. The probability of the termination in recovery does not depend so much on the actual severity of the immediate symptoms that may have been occasioned by the accident, as on their persistence. If they continue beyond a certain time, changes will take place in the cord and its membranes which are incompatible with the proper exercise of its functions.

Injuries of the Vertebral Column in Concussion.—In concussion of the spinal cord, there is, in addition to the lesion of the cord, serious injury inflicted on the ligamentous and bony structures of the vertebral column. This injury, however, must be considered as an accidental complication, as it does not necessarily occasion, or even aggravate, the mischief done to the cord. Thus the ligaments may be torn through so as to allow partial separation of contiguous vertebræ; or, a vertebra may be fractured, but without any displacement of the broken fragments, or other sign by which it is possible during life to determine the exact amount of injury inflicted on the parts external to the cord. In this respect injuries of the spine closely resemble those of the head; their chief importance depending on the amount of injury inflicted upon the contained parts. In the spine, as in the head, it will sometimes be found after death from what appears to be, and in reality is, simple injury of the nervous centres, that the vertebral column in the one case, and the skull in the other, has suffered an amount of injury unsuspected during life; and which, though it may not in any way have determined the fatal result, yet affords conclusive evidence of the violence to which the parts have been subjected, and the intensity of the disorganizing shock that they have suffered. There is, however, a very essential difference between the spine and the head. A simple fracture of the cranium may be of no moment, except so far as the violence that has occasioned it may have influenced the brain. In the spine, the case is not parallel; for, as the vertebral column is the centre of support to the body, its function in this respect will be lost when it is broken; even though the spinal cord may not have been injured by the edges of the fractured vertebræ, but simply violently and fatally concussed by the same force that broke the spine.

Boyer noticed the very interesting practical fact, that, when the interspinous ligaments were ruptured in consequence of forcible flexion of the spine forwards, no fatal consequences usually ensued, the integrity of the parts being restored by rest; but that, when the ligamenta subflava were torn through, and the arches separated, paraplegia and death followed. This he attributed to stretching of the spinal cord. Sir C. Bell, however, with great acuteness, has pointed out the error of this explanation, and states that "it is the progress of the inflammation to the spinal marrow, and not the pressure or the extension of it, which makes these cases of subluxation and breach of the tube fatal." There can be no doubt that this explanation is the correct one; and that, when once the spinal canal is forcibly torn open, fatal inflammation will spread to the meninges and to the medulla itself.

Effects of Slight Blows.—The consideration of the effects that may be produced on the spinal cord by *slight blows*, whether applied to the back or to a distant part of the body, has long arrested the attention of observant practitioners. Abercrombie, writing in 1829, says, that chronic inflammation of the cord and its membranes "may supervene upon very slight injuries of the

spine." He says also: "Every injury of the spine should be considered as deserving of minute attention. The more immediate cause of anxiety in such cases is inflammatory action, which may be of an acute or chronic kind; and we have seen that it may advance in a very insidious manner even after injuries that were of so slight a kind that they attracted at the time little or no attention." Nothing can be clearer and more positive than this statement. These remarks of Abercrombie are confirmed by Ollivier, by Bell, and by other writers on such injuries.

Concussion from Indirect Violence.—There is a class of cases of an extremely insidious and protracted character, in which the patient has received no blow or injury upon the head or spine, but the whole system has had a severe shake or shock, in consequence of which disease is developed in the spinal cord, perhaps eventually extending to the membranes of the brain. These cases are more frequent in railway than in other injuries; but they occasionally occur in consequence of ordinary accidents.

One of the most remarkable circumstances connected with injuries of the spinal cord is, the disproportion between the accident and the mischief produced thereby. Not only do most serious, progressive, and persistent symptoms of concussion of the spinal cord often develop themselves after apparently slight injuries, but frequently when there is no sign whatever of external lesion. The shake or jar inflicted on the spine when a person jumping from the height of a few feet comes to the ground suddenly and heavily on his heels or in a sitting posture, has been well known to Surgeons as a not uncommon cause of spinal weakness and debility. It is the same in railway accidents; the shock to which the patient is subjected being often followed by a train of slowly progressive symptoms, indicative of concussion and subsequent irritation and inflammation of the cord and its membranes.

It is worthy of remark, that the symptoms of spinal concussion seldom occur when a serious injury has been inflicted on one of the limbs, unless the spine itself have at the same time been directly and severely struck. A person who by any ordinary accident has one of his limbs fractured or dislocated necessarily sustains a very severe shock; but it is extremely rare to find that the spinal cord or the brain has been injuriously influenced. It would appear as if the violence of the shock expends itself in the production of the fracture or the dislocation, and that a jar of the more delicate nervous structures is thus avoided. A familiar illustration of this is afforded in the injury sustained by a watch by falling on the ground. A watchmaker once told me that, if the glass be broken, the works are rarely damaged; if the glass escape unbroken, the jar of the fall will usually be found to have stopped the movement.

How these jars, shakes, shocks, or concussions of the spinal cord directly influence its action, I cannot say with certainty. When a magnet is struck a heavy blow with a hammer, the magnetic force is jarred, shaken, or concussed out of the iron. So, if the spine be severely jarred, shaken, or concussed by a blow or shock of any kind communicated to the body, we find that the nervous force is to a certain extent shaken out of the man, and that he has in some way lost nervous power. What immediate change, if any, has taken place in the nervous structure to occasion that effect, we no more know than what change happens to a magnet when struck.

There is a peculiar train of symptoms of the following character sometimes met with in concussion of the spine, from whatever cause it may occur. The

patient struck on the lower dorsal region feels as if an electric shock had passed through him ; he becomes feeble, and scarcely able to stand or walk. He takes to his bed, and for several days passes scarcely any urine, micturating only once in twenty-four or thirty-six hours. There is no distension of the bladder from retention ; but little or no urine is secreted. On passing the catheter the bladder will be found to contain not more than from six to eight ounces. The cutaneous sensibility of the lower extremities is gradually diminished until it becomes entirely lost. There is no reflex movement on tickling the soles of the feet, and no electric sensibility, usually as high as the knees; sometimes the anæsthesia extends much higher. The patellar reflex, electric irritability and muscular tonicity continue for a time unimpaired, perhaps exaggerated, then decline, paresis of the lower limbs setting in. The temperature of the extremities and mouth falls much below normal. The patient becomes anæmic, wastes, and is emotional, a hysterical condition developing. This state may continue for many months, a year, or two even, with many intercurring neurotic phenomena. But however hopeless the case may appear, recovery may be anticipated with confidence, though some years may elapse before this is complete.

Secondary Effects.—Whatever may be the nature of the primary change that is produced in the spinal cord by a concussion, the *secondary effects* are clearly inflammatory, and are identical with those phenomena that have been described by Ollivier, Abercrombie, and others, as dependent on chronic meningitis of the cord, and subacute myelitis.

One of the most remarkable phenomena attendant upon this class of cases is, that at the time of the occurrence of the injury the sufferer is usually quite unconscious that any serious accident has happened to him. *The period of the supervention* of the more serious, persistent, and positive symptoms of spinal lesion will vary greatly. Most commonly, after the first and immediate effects of the accident have passed off, there is a period of comparative ease, and of remission of the symptoms, during which the patient imagines that he will speedily regain his health and strength. This period may last for many weeks, possibly for two or three months. Although there is often this long interval between the time of the occurrence of the accident and the supervention of the more distressing symptoms, it will be found, on close inquiry, *that there has never been an interval of complete restoration to health.* His friends remark, and he feels that "he is not the man he was." He has lost bodily energy, mental capacity, and business aptitude. He looks ill and worn ; often becomes irritable and easily fatigued. He still believes that he has sustained no serious or permanent hurt, and so long as he is at rest, he will feel tolerably well ; but any attempt at ordinary exertion of body or mind brings back all those feelings or indications of nervous prostration and irritation characteristic of these injuries ; and to them will gradually be superadded more serious symptoms which evidently proceed from a chronic disease of the cord and its membranes. After a lapse of several months—from three to six—the patient will find that he is slowly but steadily becoming worse, and he then, perhaps for the first time, becomes aware of the serious and deep-seated injury that his nervous system has sustained.

The *countenance* is usually pallid, sometimes even livid, and has a peculiarly careworn, expressionless look—the patient generally looking much older than he really is, or than he did before the accident. I have, however, seen instances

of flushing of the face, apparently due to lesion of the sympathetic and disturbance of its vaso-motor action.

In all cases of concussion of the spinal cord, followed by secondary consequences, it will be found that the *brain* participates, after a time, in the general disturbance of the nervous system. The *thoughts* are confused. The patient cannot concentrate his ideas so as to carry out a connected line of reasoning ; he attempts to read, but is obliged to lay aside the book or paper after a few minutes' attempt at perusal. All *business-aptitude* is lost ; partly from impairment of memory, partly from confusion of thought and inability to concentrate ideas for a sufficient length of time. The *temper* often becomes changed for the worse, the patient being fretful, irritable, and in some way—difficult perhaps to define, but easily appreciated by those around him—altered in character.

The *sleep* is disturbed, restless, and broken. The patient wakes up in sudden alarm ; dreams much ; the dreams are distressing and horrible.

The *head* is usually of its natural temperature, but sometimes hot. The patient complains of various uneasy sensations in it ; of pain, tension, weight, or throbbing ; of giddiness ; of a confused or strained feeling in it ; and frequently of loud and incessant noises, described as roaring, rushing, ringing, singing, sawing, rumbling, or thundering. These noises vary in intensity at different periods of the day ; but, if once they occur, they are never entirely absent, and are a source of great distress.

The *organs of special sense* usually become more or less seriously affected, being sometimes over-sensitive and irritable, whilst at others their functions are impaired or perverted. In many cases we find a combination of all these conditions in the same organ. *Vision* may be affected in various ways and in very different degrees. These affections of the eye are so characteristic and important that they will be described separately further on.

The *hearing* may be variously affected. Not only does the patient commonly complain of the noises in the head and ears that have already been described, but the ears, like the eyes, may be over-sensitive or too dull. One ear is frequently over-sensitive, whilst the other is less acute than it was before the accident. Loud and sudden noises are peculiarly distressing to these patients. *Taste* and *smell* are sometimes, but more rarely, perverted.

The *sense of touch* is impaired. The patient cannot pick up a pin, cannot button his dress, cannot feel the difference between different textures, as cloth and velvet. He loses the sense of *weight*, and cannot tell, for instance, whether a sovereign or a shilling is balanced on his finger. *Speech* is rarely affected. The *attitude* is stiff and unbending. The patient holds himself very erect, usually walks straight forwards, as if afraid or unable to turn to either side. The *movements of the head or trunk*, or both, do not possess their natural freedom. There may be pain or difficulty in moving the head in the antero-posterior direction, or in rotating it ; or all movements may be attended by so much pain and difficulty that the patient is afraid to attempt them, and hence keeps the head in an attitude of immobility. The movements of the trunk are often equally restrained, especially in the lumbar region. Flexion forwards, backwards, or sideways, is painful, difficult, and may be impossible ; flexion backwards is usually most complained of. If the patient be desired to stoop and pick anything off the ground, he will not be able to do so in the usual way, but bends down on the knee and so reaches the ground. If

he be laid horizontally, and told to raise himself into the sitting posture, without the use of his hands, he will be unable to do it.

The *state of the spine* will be found to be the real cause of these symptoms. On examining it by pressure, by percussion, or by the application of the hot sponge, it will be found that it is painful, and that its sensibility is exalted at one, two, or three points. These are usually the upper cervical, the middle dorsal, and the lumbar regions. The exact vertebræ that are affected vary necessarily in different cases; but the exalted sensibility always includes two, and usually three, at each of these points. It is in consequence of the pain that is occasioned by any movement of the trunk in the way of flexion or rotation, that the spine loses its natural suppleness, and moves as a whole—as if cut out of one solid piece—instead of with its usual flexibility.

The *movements of the head upon the upper cervical vertebræ* are variously affected. In some cases, the head moves freely in all directions, without pain or stiffness. In other cases, the greatest agony is induced if the Surgeon take the head between his hands and bend it forwards or rotate it; the articulations between the occipital bone, the atlas, and the axis, being evidently inflamed. The *pain* is usually confined to the vertebral column, and does not extend beyond the transverse processes, but, in some instances, it extends widely over the back on both sides, and seems to correspond with the distribution of the posterior branches of the dorsal nerves. In these cases, from the musculo-cutaneous distribution of these nerves, the pain is superficial and cutaneous as well as deeply seated.

The *muscles of the back* are usually unaffected; but in some cases, where the muscular branches of the dorsal nerves are affected, they may become very irritable and spasmodically contracted, so that their outlines are very distinct.

The *gait* of the patient is characteristic. He walks more or less unsteadily, generally uses a stick, or, if deprived of that, is apt to lay his hand on any article of furniture that is near to him, for the purpose of steadying himself. He keeps his feet somewhat apart, so as to increase the basis of support, and consequently walks in a straddling manner. As one leg is often weaker than the other, he totters somewhat, and raises the foot but slightly off the ground, so that the heel is apt to touch. He seldom drags the toe; but, as he walks flat-footed as it were on one side, the heel drags. This peculiar straddling, tottering, unsteady gait, with the spine rigid, the head erect, and looking straight forwards, gives the patient the aspect of a man who walks blindfolded. The patient cannot generally stand equally well on either foot. One leg usually gives way immediately under him if he attempt to stand on it. He often cannot raise himself on his toes, or stand on them, without immediately tottering forwards. His power of walking is always very limited, seldom exceeding half a mile or a mile at the utmost. He cannot ride, even if much in the habit of doing so before the accident. There is usually considerable difficulty in going up and down stairs—more difficulty in going down than up. The patient is obliged to support himself by holding on to the balusters, and often brings both feet together on the same step.

A *sensation as of a cord tied round the waist*, with occasional spasm of the diaphragm, giving rise to a catch in the breathing, or hiccup, is sometimes met with, and is very distressing when it does occur.

The *nervous power of the limbs* will be found to be variously modified, and will generally be so to very different degrees in the different limbs. Some-

times one limb only is affected; in other cases the arm and leg on one side, or both legs only, or the arm and both legs, or all four limbs, are the seat of uneasy sensations. There is the greatest possible variety in these respects, dependent of course entirely upon the degree and extent of the lesion that has been inflicted upon or induced in the spinal cord. Sensation or motion may be affected; or both may suffer, either alike or in unequal degrees. Sensation and motion may both be seriously impaired in one limb, or sensation in one and motion in another. The paralysis is seldom complete. It may become so in the more advanced stages, after several years; but for the first year or two it is almost always partial. It is sometimes incompletely recovered from, especially so far as sensation is concerned.

The *loss of motor power* is especially marked in the legs, and more often in the extensor than in the flexor muscles. The extensor of the great toe is especially apt to suffer. The hand and arm are less frequently the seat of loss of motor power than the leg and foot; but the muscles of the ball of the thumb, or the flexors of the fingers, may be affected. The loss of motor power in the foot and leg is best tested by the application of the galvanic current, so as to compare the irritability of the same muscles of the opposite limbs. The electric test is not under the influence of the patient's will; and a very true estimate can thus be made of the loss of contractility in any given set of muscles. The loss of motor power in the hand is best tested by the force of the patient's grasp. This may be roughly estimated by telling him to squeeze the Surgeon's fingers, first with one hand and then with the other, or more accurately by means of the dynamometer, which shows on an index the precise amount of pressure exercised in grasping. It is in consequence of the diminution of motor power in the legs that those peculiarities of gait which have been above described are met with, and they are most marked when the amount of loss is unequal in the two limbs.

Modification or diminution of sensation in the limbs is one of the most marked phenomena in these cases. In many instances the sensibility is a good deal augmented, especially in the earlier stages. The patient complains of shooting pains down the limbs, like stabs, darts, or electrical shocks. The surface of the skin is sometimes over-sensitive in places on the back; or, in various parts of the limbs, hot, burning sensations are experienced. After a time these sensations give place to various others, which are very differently described by patients. Tingling, a feeling of "pins and needles," a heavy sensation, as if the limb were asleep, creeping sensations down the back and along the nerves, and formication, are all commonly complained of. These sensations are often confined to one nerve in a limb, as the ulnar or the musculo-spiral. Numbness, more or less complete, may exist independently of, or be associated with, all these various modifications of sensation. It may be confined to a part of a limb, may influence the whole of it, or may extend to several limbs. Its degree and extent are best tested by Brown-Séquard's æsthesiometer.

In determining the condition of the spinal cord, special attention must be paid to the *tendon reflexes*, and to the *electric irritability* of particular groups of muscles. It would be altogether foreign to the scope of this work to describe the significance of the various phenomena presented by these several means of diagnosis. But it may be stated generally that in sub-inflammatory and inflammatory conditions the reflex manifestations are more active and the

electric irritability of muscles more intense than natural; whilst when the lesion of the cord has advanced to disintegration of its substance they are proportionately diminished or lost. But in practice these two conditions of inflammation and of disorganization are so frequently combined in varying degrees that proportionate modifications of reflex and electric phenomena occur. And it is in determining the value and true significance of these that the diagnostic skill of the physician is shown.

Coldness of one of the extremities, dependent upon loss of nervous power and defective nutrition, is often perceptible to the touch, and may be determined by the thermometer; but in many cases the sensation of coldness is far greater to the patient than it is to the Surgeon's hand, and not unfrequently no appreciable difference in the temperature of two limbs can be determined by the most delicate clinical thermometer, although the patient experiences a very distinct and distressing sense of coldness in one limb.

The condition of the limbs as to *size*, and the *state of their muscles*, will vary greatly. In some cases of complete paraplegia, which has lasted for years, it has been remarked that no diminution whatever has taken place in the size of the limbs. It is evident, therefore, that loss of size in a limb that is more or less completely paralysed is not the simple consequence of the disuse of the muscles; or it would always occur. But it must arise from some modification of innervation, influencing the nutrition of the limb, independently of the loss of its muscular activity. In most cases, however, where the paralytic condition has been of some duration, the limb, on accurate measurement, will be found to be somewhat smaller in circumference than its fellow on the opposite side. Most commonly when a limb dwindles the muscles become soft, and the intermuscular spaces more distinct. Occasionally, in advanced cases, some contraction and rigidity in particular muscles set in. Thus the flexors of the little and ring fingers, the extensors of the great toe, the deltoid or the muscles of the calf, may all become more or less rigid and contracted.

The *body* itself generally loses weight; and a loss of weight, when the patient is rendered inactive by a semi-paralysed state, and takes a fair quantity of good food, which he digests sufficiently well, may usually be taken to be indicative of progressive disease in the nervous system. When the progress of the disease has been arrested, though the patient may be permanently paralysed, a considerable increase of size and weight often takes place. This is a phenomenon of common occurrence in ordinary cases of paralysis from disease of the brain.

The condition of the *genito-urinary* organs is seldom much deranged in the cases under consideration. Sometimes there is suppression of urine more or less complete for two or three days; retention very rarely occurs. Sometimes irritability of the bladder is a prominent symptom. The urine generally retains its acidity, sometimes markedly, at others but very slightly. As there is no retention, it does not become alkaline, ammoniacal, or otherwise offensive. The sexual desire and power are usually greatly impaired, and often entirely lost; not invariably so, however. I have never heard priapism complained of.

The contractility of the *sphincter ani* has not, in any case which I have observed, been so far impaired as to lead to involuntary escape of flatus or of fæces.

The *heart* will often continue to beat in a violent or tumultuous manner for

many months after the receipt of a spinal concussion or severe nervous shock, the pulse however being feeble. This disproportion between the force of the heart's action and that of the pulse is very marked in many of these cases, and is an additional proof if any were needed of the important part played by the sympathetic in these cases.

The **Progressive Development of the various symptoms** that have just been detailed extends usually over a lengthened period. In the early stages, the chief complaint is a sensation of lassitude, weariness, and inability for mental and physical exertion. Then come the pains, tinglings, and numbness of the limbs; next the fixed pain and rigidity of the spine; then the mental confusion and signs of cerebral disturbance, and the affection of the organs of sense; the loss of motor power, and the peculiarity of gait. It is by this chain of symptoms, which, though fluctuating in intensity, is yet continuous and unbroken, that the injury sustained, and the illness subsequently developed, can be linked together in the relation of cause and effect.

Impairment of Vision from Spinal Injury.*—One of the most frequent and most troublesome effects of spinal injury is a certain degree of impairment of vision, which assumes different characters, and comes on at very varying periods after the injury. Often a considerable interval intervenes between the occurrence of the injury and the development of the eye-symptoms; and, if the patient be confined to bed, and be not called upon to use his eyes, it may be long before he discovers that their sight is enfeebled. This is more especially apt to be the case, as the attention of the Surgeon may not be directed to the state of the eyes in the first instance. The first and most frequent symptom that is complained of is a dimness or weakness of the sight, so that the patient cannot define the outlines of small objects, and cannot see in an obscure light. If he attempt to read, he can define the letters often of the smallest print for a few seconds or minutes, but they soon run into one another, become obscured and blurred, and ill-defined. Glasses do not materially, if at all, improve this condition. There is often in the early stages some slight irregularity in the axis of the eyes, scarcely amounting, however, to a squint. This blurring, or indistinctness of vision, is often more marked with respect to near than to distant objects. After a time the patient usually suffers from irritability of the eyes, and cannot bear a strong light, even that of an ordinary window, in the daytime, or unshaded gas or lamplight. In consequence of this irritability of the eyes, the brows become involuntarily contracted, and the patient acquires a peculiar frown so as to exclude light as much as possible. This intolerance of light may amount to perfect photophobia, and is then associated with congestion of the conjunctiva and accompanied by lachrymation. One or both eyes may be thus affected. This intolerance of light is usually accompanied by muscæ volitantes and spectra, rings, stars, spots, flashes, and sparks, or an appearance of white-coloured flame. The appearance of a fixed luminous spectrum, a line, circle, or coloured bar across the field of vision, is sometimes complained of. There is an undue retention of the image in many cases; and where the patient has looked at any fixed object, such as the sun or the fire, complementary spectral colours, often of the most beautiful character, of varying degrees of intensity,

* For a fuller consideration of the subject of *Impairment of Vision as a Consequence of Injuries of the Nervous System*, I would refer the reader to Lecture 10, "Concussion of the Spine," by the Author. Longmans, 1882.

will develop themselves in succession. The patient is in some cases conscious of the circulation in his own eye, which becomes distinctly visible to him, even in its pulsatory character.

From this description of the symptoms of the impairment of vision that follows spinal injury, it would appear that it is of five distinct kinds, which may, however, be associated: 1. Asthenopia, or simple weakness of sight; 2. Amblyopia, a paresis of the optic nerve or retina; 3. Loss or failure of the power of accommodation; 4. Irritability of the eye and photopsia from hyperæmia or inflammation of the optic nerve and retina, which may lead to, 5. Atrophy of the optic nerve.

The objective phenomena presented by the eye, and the ophthalmoscopic

Fig. 328—Use of the Opthalmoscope.

appearances seen in the interior of the globe in these cases, have been carefully studied by Wharton Jones and Allbutt. Jones, in his able work "On Failure of Sight after Railway and other Injuries," states that the eyelids are usually half closed; the eyes sunken and watery; the veins of the eyeball congested. The movements of the pupils are sometimes normal; sometimes more sluggish, sometimes more active than usual. This will necessarily depend upon whether the eye be affected by simple asthenopia, or whether there be some hyperæmic or inflammatory state developed in its interior.

The ophthalmoscopic appearances vary greatly. In some cases, as Wharton Jones observes, the morbid state on which the failure of sight and other subjective symptoms depend, may be at first confined to some central portion of the optic nervous apparatus, and no ophthalmoscopic evidence of implication of the retina or optic disc may present itself till a more advanced stage of the case. Sooner or later, however, whether as the result of primary changes in the fundus, or more slowly from the effect of a slowly progressive inflamma-

tory affection propagated from the intracranial portion of the nervous apparatus towards its periphery, and thus inducing morbid changes in the optic nerve and its disc, we find that the ophthalmoscope reveals changes in the fundus of the eye. "The disc," says Wharton Jones, "is seen to be whitish and somewhat congested; the retinal veins are large, though the fundus usually presents an anæmic aspect, with perhaps some pigmentous degeneration of the retina round the disc."

One or other of these conditions occurs in the majority of cases of spinal injury. Allbutt says: "It is tolerably certain that disturbance of the optic disc and its neighbourhood is seen to follow disturbance of the spine, with sufficient frequency and uniformity to establish the probability of a causal relation between the two events." He goes on to say that in 13 cases of chronic spinal disease following accident, he found 8 cases of sympathetic disorder of the eye. My experience fully accords with that of Allbutt. I find that of 60 cases of obscure spinal injury, without fracture or dislocation, that I have consecutively examined, there was impairment of vision in 42 instances.

Allbutt makes the interesting remark, which will be supported by the experience of all Surgeons, that, in the severer forms of spinal injury, those that prove fatal in a few weeks, evidences of eye-disease are not met with. Of 17 such cases he found no evidence of eye-disease in any one instance. This observation affords a most complete answer to an objection that has often been urged, that as sympathetic affection of the eye is rarely met with in severe injuries of the spine, such as fractures and displacement of the vertebræ with traumatic lesion of the cord, its occurrence in the less immediately severe and more obscure forms of injury can scarcely be looked upon as the direct result of the spinal mischief. It would appear, however, from the observations of Allbutt, which I can entirely confirm, that it is in these very cases that it is met with. That a certain portion of the spinal cord exercises a direct influence on the eyes, has been incontestably established by the experiments of modern physiologists. Budge and Waller, in 1851, demonstrated that the filaments of the sympathetic that supply the eye take their origin from that part of the spinal cord which is contiguous to the origin of the first pair of dorsal nerves; and that the portion of the spinal axis which extends from the fifth cervical to the sixth dorsal vertebra, and, according to Brown-Séquard, as far as the twelfth dorsal, possesses a distinct influence on the organs of vision. Hence by these physiologists it has been termed the "cilio-spinal," and by Claude Bernard the "oculo-spinal" axis. It has been determined as the result of numerous experiments, that partial division of this cilio-spinal axis exercises various disturbing influences on the size of the pupils, on the fulness of the vessels of the conjunctiva, and probably of the deeper ocular tissues, and on the state of the blood-vessels of the ear, exactly similar to those that are occasioned by section of the cervical sympathetic. The conclusion that must necessarily be deduced from these observations is, that this portion of the spinal cord—the *oculo-spinal axis*—includes within itself both vaso-motor and oculo-pupillary filaments which are connected with the cervical portion of the sympathetic. Claude Bernard has pointed out clearly the fact that the vaso-motor and the oculo-pupillary nerves possess different reflex actions. By dividing the first two dorso-spinal roots, he finds that the oculo-pupillar phenomena are produced without occasioning the vaso-motor effects of vascular injection and

increase of temperature; whereas, by dividing the ascending sympathetic filament between the second and third ribs, the vaso-motor phenomena are developed in the head without any influence being excited on the eye through the medium of the oculo-pupillary filaments. He sums up his observations as follows. "The vaso-motor and the oculo-pupillary nerves do not act in the same way. Thus a slight irritation of the auricular nerve occasions only vascular dilatation on the corresponding side; whilst the same irritation produces reflex movements in both eyes at the same time. The reflex vascular actions do not appear to be capable of being produced on the opposite side to that which is irritated (d'une manière croisée); and, besides this, they are limited and do not extend beyond a certain determined line of circumscription. All this is in striking contrast with the oculo-pupillar actions, which are on the contrary general and crossed."

Clinical observations support the result of physiological experiment as to the connection that exists between the oculo-spinal axis of the cord and the integrity of vision. The records of surgery contain numerous illustrations of the injurious influence on the sight of blows inflicted on the lower cervical and upper dorsal spine. Allbutt remarks, that those injuries and concussions of the spine that occur high up are more injurious to vision than such as are inflicted on the lower portion of the vertebral column.

To what is this impairment of vision due? Allbutt, who has studied the subject with much care, gives his opinion, in which I fully coincide, so clearly, that I cannot do better than quote his own words. "In default of a series of autopsies, we seem to be led towards the conjecture that hyperæmia of the back of the eye, following injury to the spine, is probably dependent upon a greater or less extension of the meningeal irritation up to the base of the brain. Now, have we any reason to suppose that spinal meningitis does creep up into the encephalon? We have: for, setting aside the curious head-symptoms such patients often present, here the actual demonstration of autopsy comes to aid us. It is tolerably well known to careful pathologists that encephalic meningitis is a very common accompaniment of spinal meningitis. It is scarcely needful to point out that, if this explanation of an ascending meningitis be the correct one, it accords with my observation, stated above, that, in general, the higher the injury to the spine, the sooner the affection of the eye."

Pathological Conditions.—Two distinct forms of chronic and subacute inflammation may affect the contents of the spinal canal, as the results of injury or of disease; viz., Inflammation of the Membranes, and Inflammation of the Cord itself.

In **Spinal Meningitis,** the usual signs of inflammatory action in the form of increased vascularity of the membranes are met with. The meningo-rachidian veins are turgid with blood, and the vessels of the pia mater are much injected, sometimes in patches, at other times uniformly. Serous fluid, reddened and clear, or opaque from the admixture of lymph, may be found largely effused in the cavity of the arachnoid. In distinguishing the various pathological appearances presented by fatal cases of chronic spinal meningitis, Ollivier makes the very important remark that spinal meningitis rarely exists without there being at the same time a more or less extensive inflammation of the cerebral meninges; and hence, he says, arises the difficulty of determining with precision the symptoms that are special to inflammation of the membranes of the spinal cord.

When **Myelitis** occurs, the inflammation attacking the substance of the cord itself, the most usual pathological condition met with is softening, with more or less disorganisation. This softening of the cord, as a consequence of inflammation, may occupy very varying extents. Sometimes the whole thickness of the cord is affected at one point, sometimes one of the lateral halves in a vertical direction ; at other times the disease is most marked in or wholly confined to its anterior or its posterior aspect ; or the grey central portion may be more affected than the circumferential part. Again, these changes of structure may be limited to one part only, to the cervical, the dorsal, or the lumbar. It is very rarely indeed that the whole length of the cord is affected. The most common seat of inflammatory softening is the lumbar region ; next in order of frequency is the cervical. In very chronic cases of myelitis, the whole of the nervous substance disappears, and nothing but connective tissue is left at the part affected. Ollivier observes that, when myelitis is consecutive to meningitis of the cord, the inflammatory softening may be confined to the white substance.

Though softening is the ordinary change that takes place in a cord that has been the seat of chronic inflammation, sometimes the nervous substance becomes increased in bulk, more solid than natural, and of a dull white colour, like boiled white of egg. This induration may co-exist with spinal meningitis, with congestion, and increased vascularization of the membranes.

It is important to observe that, although spinal meningitis and myelitis are occasionally met with distinct and separate, yet they most frequently co-exist. When existing together, and even arising from the same cause, they may be associated in very varying degrees. In some cases the symptoms of meningitis, in others those of myelitis, are most marked ; and, after death, corresponding characteristic appearances are found.

Diagnosis.—There are four morbid states, with one or other of which the symptoms of spinal concussion, which have been just described, have sometimes been confounded, and from which it is necessary to diagnose it. These are, 1. The Secondary Consequences of Cerebral Concussion ; 2. Rheumatism ; 3. Hysteria ; and 4. Syphiloma of the Cord.

1. From the **secondary effects of cerebral concussion** it is not difficult to diagnose the consequences of concussion of the spinal cord, in those cases in which the mischief is limited to the vertebral column. The tenderness and rigidity of the spine, the pain on pressing upon or on moving it in any direction, and the absence of any distinct lesion about the head, will sufficiently mark the precise situation of the injury.

The two conditions of cerebral and spinal concussion often co-exist primarily. The shock that jars injuriously one portion of the nervous system, very commonly produces a corresponding effect on the whole of it, on the brain as well as on the cord ; and the secondary inflammations of the spine, which follow the concussion, even when that is primarily limited to the vertebral column and its contents, have a tendency to extend along the continuous fibrous and serous membranes to the interior of the cranium, and thus to give rise to symptoms of cerebral irritation.

2. From **rheumatism** the diagnosis may not always be easy, especially in the earlier stages of the disease, when the concussion of the spine and the consecutive meningitis have developed pain along the course of the nerves, and increased cutaneous sensibility at points. By attention, however, to the history

of the case, the gradually progressive character of the symptoms of spinal concussion, the absence of all fixed pain except at one or more points in the back, the cerebral complications, the gradual occurrence of loss of sensibility, of tinglings and formications, the slow supervention of impairment or loss of motor power in certain sets of muscles (symptoms that do not occur in rheumatism), the diagnosis will be rendered comparatively easy; the more so, when we observe that in spinal concussion there is never any concomitant articular inflammation, and that, although the urine may continue acid, it does not usually show a superabundance of lithates.

3. **Hysteria** is the disease for which I have more frequently seen concussion of the spine, followed by meningo-myelitis, mistaken; and it has always appeared extraordinary to me that so great an error of diagnosis could easily be made. Hysteria, whether in its emotional or its local form, is a disease of women rather than of men, of the young rather than of the middle-aged and old, of people of an excitable, imaginative, or emotional disposition rather than of hard-headed, active, practical men of business. It is a disease that runs no definite or progessive course, that assumes no permanence of action, that is ever varying in the intensity, in the degree, and in the nature of its symptoms; that is marked by excessive and violent outbreaks of an emotional character, or by severe exacerbations of its local symptoms; but that is equally characterized by long-continued and complete intermissions of its various phenomena. This in no way resembles what we see in concussion of the spinal cord, or in the consecutive meningo-myelitis; and it seems to me quite unreasonable to call a case one of hysteria in which a man active in mind, accustomed to self-control, devoted to business, suddenly, and for the first time in his life, after the infliction of a severe shock, finds himself affected by a train of symptoms indicative of serious and deep-seated injury to the nervous system. In reality, there can be but little difficulty in establishing the diagnosis between chronic meningo-myelitis and hysteria. The persistence of the symptoms, their slow development, their progressive increase in severity, notwithstanding occasional fluctuations and intermissions in intensity, the invariable presence of more or less paralysis of sensation, or of motion, or both, will easily enable the Surgeon to judge of the true nature of the case. That mental emotion is occasionally manifested by an unfortunate individual who has been seriously injured by an accident which tends to shake his whole nervous system, can scarcely be matter of surprise; but the term "hysteria," elastic as it is, cannot, it appears to me, be strained so far as to include this condition; and even if it be considered applicable to the patient's mental state, it can in no way be looked upon as the cause of those bodily sufferings and disabilities which constitute the most important and serious part of the disease.

4. **Syphiloma of the Cord and its Membranes** is a condition that may be confounded with the effects of concussion, and when it already exists its symptoms may be greatly aggravated, or the disease called into activity by the injury. In these cases the antecedent history, and the concomitant evidence of constitutional syphilis in one of its minor forms perhaps will determine the diagnosis.

Prognosis.—The prognosis of concussion of the spinal cord and that of the consecutive meningo-myelitis is a question of extreme interest in a medico-legal point of view, and is often involved in much difficulty.

The prognosis requires to be made with regard, first to the life, and secondly

to the health of the patient. So far as life is concerned, it is only in cases of severe and direct blows upon the spine, causing intraspinal hæmorrhage to a considerable extent or rupture of the cord or its membranes that a speedily fatal termination may be feared.

In some cases of concussion of the spine, followed by chronic inflammation of the membranes and of the cord itself, death may supervene after several, perhaps three or four, years of increasingly progressive breaking-down of the general health, and slow extension of the paralytic symptoms. I have heard of several instances in which concussion of the spine has thus proved fatal some years after the occurrence of the accident. I have never known a patient recover who has been attacked by convulsions, progressive paralysis developing itself, and the case ultimately proving fatal. Gore, of Bath, informs me that he is acquainted with two cases which proved fatal at long periods of time after the accident, in both of which this symptom was present. Concussion of the spine may prove fatal: first, at an early period from the severity of the direct injury; secondly, at a more remote date from inflammation of the cord and its membranes; and, thirdly, after a lapse of several years, from slow and progressive development of structural changes in the cord and its membranes.

If death do not occur, is recovery certain? Is there no intermediate state between a fatal result, proximate or remote, and absolute and complete recovery? In considering the question of recovery after concussion of the spine, we have to look to two points: first, recovery from the primary and direct effects of the injury; and, secondly, recovery from the secondary and remote consequences. There can be no doubt that recovery, entire and complete, may occur in a case of concussion of the spine, when the symptoms have not gone beyond the primary stage, when no inflammation of the cord or its membranes has been developed, and more particularly when the patient is young and healthy. This last condition indeed is most important. A healthy young man is not only less likely to suffer from a severe shock to the system from a fall or railway-injury than one more advanced in life: but, if he do suffer, his chance of ultimate recovery will be greater, provided always that no secondary structural lesions have developed. I believe that such recovery is more likely to ensue if the primary and direct symptoms have been severe, and have at or almost immediately after the occurrence of the accident attained to their full intensity. In these cases, under proper treatment, the severity of the symptoms gradually subsides, and, week by week, the patient feels himself stronger and better, until, usually in from three to six months at the utmost, all traces of the injury have disappeared.

Incomplete or partial recovery is not unfrequent in cases of severe and direct injury to the spine. The patient slowly recovers up to a certain point and then remains stationary, with some impairment of innervation in the shape of partial paralysis of sensation or of motion, or both; and usually in the lower limbs. The intellectual faculties or the organs of sense are more or less disturbed, weakened, or irritated, the constitution is shattered, and the patient presents a prematurely worn and aged look. In such cases structural lesion of some kind, in the membranes, if not in the cord, has taken place, which necessarily must prevent complete recovery.

When, therefore, we find a patient who, after the receipt of a severe injury of the spine by which the cord has been concussed, presents the primary and immediate symptoms of that condition, we may entertain a favourable opinion

of his future condition, provided there be a progressive amelioration of his symptoms, and no evidence of the development of any inflammation, acute or chronic, of the membranes of the cord. But our opinion as to his ultimate recovery must necessarily be very unfavourable if the progress of amendment cease after some weeks or months, leaving a state of impaired innervation; the more so if, subsequently to the primary and immediate effect of the injury, symptoms of meningo-myelitis have declared themselves. In such circumstances partial restoration to health may be looked for, but complete recovery is scarcely possible.

When a person has received a concussion of the spinal cord from a jar or shake of the body, without any direct blow on the back, or perhaps on any other part of the body, and the symptoms have progressively developed themselves, the prognosis will always be very unfavourable; for this reason, that, as the injury is not sufficient of itself to produce a direct and immediate lesion of the cord, any symptoms that subsequently appear must be the result of structural changes in it consequent on its inflammation; and these secondary structural changes, being incurable, must to a greater or less degree, but permanently, injuriously influence its action. For the same reason, the occurrence of a lengthened interval, a period of several weeks for instance, between the infliction of the injury and the development of the spinal symptoms, is peculiarly unfavourable. In forming an opinion as to the patient's probable future state, it is of far less importance to look to the immediate or early severity of the symptoms than to their progressive and insidious development.

The time that the symptoms have lasted is necessarily a most important matter for consideration. When they have been of but short duration, they may possibly be dependent on conditions that are completely, and perhaps easily, removable by proper treatment; for instance, on extravasation of blood, or on acute serous inflammatory effusion. But when the symptoms, however slight they may be, have continued even without progressive increase, remain stationary for a period of many months, they will undoubtedly be found to depend on those secondary structural changes that follow inflammation. I have never known a patient to recover entirely the state of health that he enjoyed before the accident, in whom the symptoms dependent on chronic inflammation of the cord and its membranes, and on their consecutive structural lesions, had existed for twelve months. And though, as Ollivier has observed, such a patient may live for fifteen or twenty years in a broken state of health, the probability is that he will die within three or four. There is no structure of the body in which a structural lesion is recovered from with so much difficulty as the spinal cord and brain. And, with the exception probably of the eye, there is no part of the body in which a slight permanent change of structure produces such serious disturbance of function as in the spinal cord.

TREATMENT.—The general principles of treatment of concussion of the spinal cord are the same, from whatever cause the injury may have arisen.

In the **Early Stages of a case of Concussion of the Spine**, the first thing to be done is undoubtedly to give the injured part complete and absolute *rest*. The importance of rest cannot be over-estimated. Without it, no other treatment is of the slightest avail; and it would be as irrational to attempt to treat an injured brain or a sprained ankle without rest, as to try to benefit a patient suffering from a severe concussion or wrench of the spine unless he be kept quiet. It is the more important to insist upon absolute and

entire rest, for the reason, that not unfrequently patients feel for a time benefited by movement ; and hence changes of air and scene are thought to be permanently beneficial. But nothing can be more erroneous than this idea, for the patient will invariably be found to fall back into a worse state than had previously existed. In more advanced stages of the disease, when chronic meningitis has set in, the patient suffers so severely from any, even the very slightest, movement of the body, that he instinctively preserves that rest which is needed.

In order to secure rest efficiently, the patient should be made to lie on a prone couch. In the prone position, the spine is the highest part of the body; thus passive venous congestion and determination of blood, which are favoured when the patient lies on his back, are entirely prevented. Again, the absence of pressure upon the back is a great comfort when it is unduly sensitive and tender, and is a source of additional safety to the patient, if he be paraplegic, by lessening the liability to the formation of bed-sores. Lastly, the prone position presents this advantage over the supine, that it allows the ready application of local treatment to the spine. In some instances complete and absolute rest may be secured to the injured spine by the application of a gutta-percha case to the back, embracing the shoulders, nape, and back of the head ; or by letting the patient wear a stiff collar, so as to give support to the neck. In other cases Sayre's plaster-of-Paris jacket will be found of the utmost service. It secures more perfect and continuous rest than any other apparatus.

But, if rest is needed to the spine, it is equally so to the brain. In cases of concussion of the spine, the membranes of the brain become liable to the extension of inflammation to them. Irritability of the senses of sight and hearing, which is very marked in many of these cases, with perhaps heat of head or flushings of the face, gives the best evidence of this morbid action. For the subdual of this state of increased cerebral excitement and irritability, it is absolutely necessary that the mind should be kept as much as possible at rest. The patient, feeling himself unequal to the fatigue of business, becomes conscious of the necessity of relinquishing it, though not perhaps without great reluctance, and until after many ineffectual efforts to attend to it. There are two remedies which may be employed with much advantage in the earlier stages of spinal concussion, with the view of soothing the irritation of the nervous system. One is chloral-hydrate, to procure sleep ; the other, bromide of potassium, to allay irritability.

During the early period of concussion of the spine, much advantage will usually be derived from dry cupping along the back on each side of the vertebral column. In some cases, I have seen good effects follow the application of ice-bags to the injured part of the spine. At this period, I believe, medicine is of little service, beyond such as is required for the regulation of the general health on ordinary medical principles.

When the **Secondary Effects of Concussion of the Spinal Cord** have appeared, much may often be done, not only for the mitigation of suffering, but for the cure of the patient, by carefully conducted local and constitutional treatment.

Rest, as in the early stages, must be persevered in ; but, in addition to this, counter-irritation may now be advantageously employed. The various forms in which this means is familiar to the Surgeon—stimulating embrocations, mustard-poultices, blisters, and setons or issues—may be successively used.

With regard to internal treatment, I know no remedy in the early period of the secondary stage, when subacute meningitis is beginning to develop itself, that exercises so marked or beneficial an influence as the perchloride of mercury in tincture of quinine or of bark. I have seen this remedy produce the most beneficial effects, and have known patients come back to the Hospital to ask for the "perchloride" as the only medicine from which they had derived advantage. At a more advanced period, and in some constitutions in which mercury is not well borne, the iodide or the bromide of potassium in full doses will be found highly beneficial, more especially when there are indications of the presence and the pressure of inflammatory effusion.

When all signs of inflammation have subsided—when the symptoms have become those of paralysis, whether of sensation or of motion—but more especially in those cases in which there is a loss of motor power, with a generally debilitated and cachectic state, cod-liver oil, strychnine, and iron may be advantageously employed. But I would particularly caution against the use of these remedies, and more especially of strychnine, in all those cases in which inflammation is still existing. In such circumstances the administration of strychnine is attended by the most prejudicial effects, increasing materially and rapidly the patient's sufferings. But in the absence of inflammatory irritation it will, if properly administered, be found to be most useful, more particularly in restoring lost motor power. In those cases in which strychnine may be advantageously administered, great benefit will be derived also from warm salt-water douches to the spine, and galvanism to the limbs.

At a more advanced period, when general cachexy has been induced, and more or less paralysis of sensation and motion continues in the limbs, and nothing of a specific nature can be done in the way of treatment, our whole object should be to improve the general health on ordinary medical principles, so as to prevent as far as possible the development of secondary diseases, such as phthisis, dependent on malnutrition and a generally broken state of health, which may after several years lead to a fatal termination.

WOUNDS OF THE SPINAL CORD.

These injuries may occur from stabs with pointed instruments; from gun-shot-violence; or, most frequently, from the pressure of fractured vertebræ. In the latter form of injury there is an association of wound and compression, giving rise essentially to the same symptoms as if the cord were divided.

Symptoms.—When the spinal cord is *completely divided*, certain symptoms occur that are common to all cases, at whatever part of the cord the injury has been inflicted, provided it be not so high as to cause instant death. In the first place, there is *complete paralysis of sensation and motion* in all the parts below the seat of injury, though the mental state of the patient continue intact. The precise seat of injury may often be diagnosed by the extent of the paralysis. In injury of the lower part of the spine, there may be paralysis of all the parts supplied by the nerves of the sacral plexus, whilst those from the lumbar are not affected; thus leading to the inference that the injury has been inflicted above the one and below the other set of nerves. When the paralysis is complete, the *temperature* below the seat of injury is *lowered*, often consider-

ably, so as to give a sensation of distinct coldness to the hand. In injuries of the cord in the cervical region, with complete paralysis below the neck, very high temperatures are occasionally met with, even as high as 114° F. When the cord is cut across, the parts below are completely paralysed, and for a time, as Savory has pointed out, reflex phenomena are abolished, owing to the lower segment of the cord sustaining, as it were, a concussion at the moment of division. After a time, however, reflex phenomena will be developed in the parts supplied by the nerves connected with the lower segment of the divided cord, which becomes, as it were, an independent excito-motor centre. Thus, when the soles of the feet are tickled, the legs will be drawn up and jerk, although all sensation is abolished. After a time visible *diminution takes place in the nutritive activity of the limbs*, the circulation becoming feeble with a tendency to congestion at depending points. The lessening of nutritive vigour is not confined to the paralysed parts, but affects the whole system, the patient becoming speedily emaciated, anæmic, and cachectic. The skin assumes a dirty, cadaverous hue, and the cuticle usually exfoliates in branny flakes.

The lowering of the temperature, the disturbance in the processes of nutrition and secretion, and the supervention of emaciation and cachexy, are dependent upon a derangement of the relations of the vaso-motor system and the spinal cord. This derangement does not altogether arise from the simple division of the cord, but is rather the consequence of the inflammation set up in it and its membranes by the injury, and is, therefore, aggravated by anything that increases the inflammation; thus it is more marked in laceration of the cord and its continuous irritation by a fractured spine, than after a simple division with a cutting instrument.

The general symptoms of paralysis following injury present important modifications, according to the height at which the cord is divided.

1. Injuries in the **Lumbar and Lower Dorsal Region**.—The cord terminates at the lower border of the first lumbar vertebra, consequently injuries below that point will affect only the spinal nerves forming the cauda equina. The whole of the nerves that enter into the lumbar and sacral plexuses arise from the part of the cord below the lower border of the eleventh dorsal vertebra. Injuries in this region consequently often cause complete paralysis of all the parts supplied from both the sacral and lumbar plexuses: sometimes, however, the sacral only is affected. When the injury affects the sacral plexus only, all the muscles below the knee, the flexors of the leg, the rotators, abductors, and extensors of the thigh are paralysed; but the extensors of the leg and the flexors and adductors retain their power. The muscles of the perinæum, the sphincter ani, and the bladder are also paralysed. Sensation is lost in the gluteal region, the back of the thigh, the outer side of the leg and foot, the genital organs, and the perinæum. When the lumbar plexus is also affected, the whole lower limb is deprived of sensation and motion, and there is some loss of sensation about the lower part of the abdomen in the part supplied by the ilio-hypogastric, but the abdominal muscles retain their power of contraction. In some cases we find complete paralysis of the parts supplied by the sacral plexus, and irregular paralysis and loss of sensation in those supplied by the lumbar plexus. This is due to injury of that part of the cord from which the sacral plexus arises, with damage to some of the lumbar nerves which lie by the side of it, before they leave the vertebral canal. In an injury completely paralysing the sacral plexus, there is always

relaxation of the sphincter ani, with consequent incontinence of flatus, and, to a great extent, of fæces. There is, at first, retention of urine in consequence of paralysis of the bladder, which is unable to expel its contents; after a time, however, the urine dribbles away as fast as it is poured into the overdistended organ, the neck of which has lost its sphincter-like action. The reason why there is incontinence of fæces but retention of urine in these cases is this. The sphincter ani and the muscular fibres of the bladder are both under the control of the spinal nerves. When paraplegia exists, the restraining power of the sphincter ani and the expelling power of the bladder are both lost. Hence the bladder cannot expel its contents: while the anus cannot retain those of the intestines, which are brought down to it by the peristaltic movements which are not spinal, but under the influence of the sympathetic nervous system. After the first few days the urine becomes ammoniacal in odour, and alkaline in reaction, in consequence of the formation of ammonium carbonate from the urea. The exact cause of this fermentative change that occurs in the urine is not clearly settled. It is invariably accompanied by the presence of microscopic organisms, which, in the opinion of many, are the direct cause of the process. Those who hold this view maintain that they are admitted from without, most commonly being introduced on the instrument with which the water is drawn off. Their growth would be favoured by the retention of urine, and especially by the accumulation of alkaline mucus in the fundus of the bladder. On this view it is possible in these cases to prevent this most serious complication. Others believe that the decomposition of the urea is due to the presence of an excess of mucus, which acts as a chemical ferment. Whatever be the cause of its decomposition, the ammoniacal urine acts as an intense irritant to the bladder, setting up severe cystitis, accompanied by an abundant secretion of viscid alkaline mucus, often mixed with pus, and sometimes with blood. Finally, it may lead to ulceration of the bladder, followed by septic poisoning by absorption from the raw surfaces; or the mischief may extend to the kidneys and terminate fatally by septic nephritis. Later in the case the bladder often becomes contracted, and dribbling of urine takes the place of retention. In the early stages of these injuries to the cord, the penis will usually be observed to be in a state of semi-erection.

Patients who have met with injuries of this portion of the spinal cord may live on for many months, or even for a year or two, in a cachectic state; death then occurs usually from sloughing of the nates, or from the effects of the diseased condition of the bladder.

2. When the cord is divided in the **Upper Dorsal Region**, about the level of the third dorsal vertebra, we have not only the train of symptoms that have just been mentioned as characteristic of this injury lower down, but respiration also is interfered with in consequence of paralysis of the greater portion of the expiratory muscles. The intercostal muscles, and those constituting the abdominal wall, no longer acting, imperfect expiration is effected solely by the elasticity of the walls of the chest; and the purely muscular expiratory movements, such as sneezing and coughing, cannot be accomplished. In these cases, during inspiration, which is effected chiefly by the diaphragm, the ribs are depressed instead of being expanded and raised: and the abdominal wall, which is soft and flaccid, is protruded far beyond its normal limits. In consequence of the impediment to respiration the blood is

not properly arterialized; and hypostatic pneumonia often causes death in two or three weeks.

3. When the injury is situated in the **Lower Cervical Region**, not only do all the preceding symptoms occur, but there is paralysis of the upper extremities as well; and, inspiration being entirely diaphragmatic, the circulation speedily becomes affected, the lungs surcharged and œdematous, and the countenance becomes suffused and purplish. If the cord have been divided immediately above the brachial plexus, there will be complete paralysis of the whole of the upper extremities; but if the injury be opposite the sixth cervical vertebra, they may be only partially paralysed. This happened in two cases of fracture of the spine in this region that were some years ago under my care at the Hospital. In both, the paralysis existed on the ulnar but not on the radial side of the arms, owing to the external cutaneous, median, and musculo-spiral nerves arising higher from the plexus than the ulnar, and thus just escaping injury. It is remarkable that, in both these cases, there was acute cutaneous sensibility in the arms along the whole line of junction between the paralysed and the sound parts. There is this remarkable fact connected with injuries of the lower portion of the cervical spinal cord, that the temperature frequently presents a marked deviation from the normal standard. In some cases it rises very considerably, in fact to a higher point than has been noticed in any other surgical affection. Brodie found in one case that the thermometer marked 111° F. But in other cases again the temperature has been found greatly reduced, even to 81° or 82° F. No explanation of these extraordinary differences has as yet been discovered. In cases of injury of the cord in this situation, death occurs usually by asphyxia in from 48 hours to a week.

When the division of the spinal cord takes place **above the Origin of the Phrenic Nerves** opposite to or above the third cervical vertebra, instantaneous death results from paralysis of the diaphragm, as well as of the rest of the respiratory muscles, inducing sudden asphyxia.

It necessarily happens in **partial division of the cord** that the symptoms are less clearly marked. In many of these cases resulting from fracture or dislocation, the symptoms due to actual injury of the cord are complicated with pressure on one or more nerves in the invertebral foramina. The most definite of these injuries are met with in partial division of the cord by a stab. In these cases it has occasionally happened that the weapon has divided one of the lateral halves of the cord. The effect of this is to cause paralysis with hyperæsthesia and elevation of temperature of the parts below the injury on the same side, with anæsthesia of the opposite side. This is owing to the chief decussation of the motor tracts taking place in the medulla oblongata, while the sensory fibres cross to the opposite side almost immediately after they enter the cord.

MECHANICAL INJURIES OF THE VERTEBRAL COLUMN.

The mechanical injuries to which the vertebral column is liable, consist of Sprains or Wrenches, Fracture, and Dislocation.

TWISTS, SPRAINS, OR WRENCHES OF THE SPINE, without fracture or dislocation of the vertebræ, may occur in a variety of ways. Boyer relates a fatal case, occurring from an injury received in practising gymnastics. Sir A. Cooper gives an instance of a fatal wrench of the spine, from a rope catching a

boy round the neck whilst swinging. In two cases under my care, the injury arose from violence applied to the cervical spine; in one from a railway-accident, in the other from a fall from a horse.

These wrenches of the spine are, for obvious reasons, most liable to occur in the more mobile parts of the vertebral column, as the neck and loins, just above the sacral region; less frequently in the dorsal region.

In railway-collisions, when a person is violently and suddenly jolted from one side of the carriage to the other, the head is frequently forcibly thrown forwards and backwards, moving as it were by its own weight, the patient having for the time lost control over the muscular structures of the neck. In such cases the patient complains of a severe straining, aching pain in the articulations between the head and the spine, and in the **Cervical Spine** itself. This pain closely resembles that felt in any joint after a severe wrench of its ligamentous structures, but is peculiarly distressing in the spine, owing to the extent to which fibrous tissue and ligament enter into the composition of the column. It is greatly increased by to-and-fro movements, however slight, and especially by rotation; also by pressure upon, and by lifting up the head so as to put the tissues on the stretch. In consequence of this, the patient keeps the neck and head immovable, rigid, looking straight forwards. He cannot raise his head off a pillow without the assistance of his own hand, or that of another person.

The **Lumbar Spine** is often strained in railway-collisions, with or without similar injury to the cervical portion of the column, in consequence of the body being forcibly swayed backwards and forwards during the jarring oscillations of the carriage on the receipt of a powerful shock. In such cases the same kind of pain is complained of. There is the same rigidly inflexible condition of the spine, with tenderness on external pressure, and great aggravation of suffering on movement, more particularly if the patient bend backwards. The patient is unable to stoop; in attempting to do so, he always goes down on one of his knees.

The muscles, especially the erector spinæ, and the fasciæ of the back are also often sprained, stretched and torn, in cases of twists and strains of the spinal column. There may be consequent swelling and induration of these tissues from the presence of inflammatory effusions and inability to use the sprained muscles. But the great danger of these sprains is, that they are not unfrequently associated with some of the most serious affections of the spinal cord that are met with in surgical practice as a consequence of injury. These may prove most dangerous, or even fatal.

The **Prognosis** will depend partly on the extent of the stretching of the muscular and ligamentous structures, partly on whether any inflammation has been excited in them which may extend to the interior of the spinal canal. As a general rule, where muscular, tendinous, and ligamentous structures have been violently stretched, as in an ordinary sprain, however severe, they recover in the course of a few weeks, or at most within three or six months. If a joint, as the shoulder or ankle, continue to be weak and preternaturally mobile, in consequence of elongation of the ligaments, or weakness or atrophy of the muscles, beyond this period, it will, in all probability, never be so strong as it was before the accident. The same holds good with the spine; and a vertebral column which has been so weakened as to require artificial support, after several months, in order to

enable it to maintain the weight of the head, will probably never regain its normal strength.

One great prospective danger in strains of the spine is the possibility of inflammation developed in the fibrous structures of the column extending to the meninges of the cord. This I have several times seen. It is particularly apt to happen when the strain or twist occurs between the occiput and the atlas or axis. In these cases a rigid tenderness is gradually developed, which is most distressing and persistent, and evidently inflammatory ; or there may be paralysis confined to the nerves that are connected with that part of the spine that is the seat of the wrench, one or other of their roots having suffered lesion, or the nervous cord itself having been injured in its passage through the intervertebral foramen. Lastly, a twist of the spine may slowly and insidiously be followed by symptoms of complete paraplegia, and eventually by death from extravasation of blood into the vertebral canal.

The *Treatment* of these injuries is the same as that of concussion of the spinal cord (see p. 783).

Fracture of the Spine may occur either by the application of direct violence, or by a violent twist or bend of the body forwards. Direct violence, as a blow, fall, or gunshot-injury, may of course fracture the spine at any part and almost to any extent, in some cases detaching merely a spinous process, in others splintering and comminuting several vertebræ and lacerating or dividing the spinal cord. Fracture of the spine from a violent but forcible bend of the body forwards occurs chiefly in the cervical region. It is produced usually by a person falling from a height on the head, the body being bent forcibly forward so as to drive the chin against the sternum. This accident often happens in falls from horseback, or in taking a "header" into shallow water. In some cases it has occurred from a person sitting on the top of a vehicle having the head forcibly bent down whilst passing under an archway. In these accidents there are usually extensive rupture of the spinal ligaments and displacement of the bones, as well as fracture.

In some cases of even very extensive fracture there may be no appreciable displacement : but usually some change of position ensues, in many cases to such an extent as to compress or lacerate the spinal cord. The mode of occurrence of the fracture will influence the amount of displacement. If the fracture be through the arch, or consist in a simple detachment of the spinous process by a fall or a blow on the back, there may be little or no displacement. If it occur from gunshot-injury, or from a fall upon the head, or by forcible flexure of the neck and body forwards, as when the body is compressed between the top of a van and an archway, there will probably be great displacement, and perhaps separation of the articulating surfaces of contiguous vertebræ. In these cases the upper part of the spine is almost invariably displaced forwards.

The **Signs** of this injury vary very greatly, and depend in a great degree upon the extent of the displacement. If this be inconsiderable, it may be extremely difficult, and even impossible in some instances, to pronounce with certainty whether the spine has been broken or not ; the more so if the fracture do not implicate the body of the vertebra. If, on the other hand, the displacement affect the axis of the column or compress the cord, the symptoms are so marked as to admit of easy diagnosis. They are of two kinds ; those presented by the injury of the bone, and those dependent on injury by compression or laceration, or both, of the spinal cord.

The **Local Signs** are usually pain at the seat of injury, greatly increased by pressure on, or motion of the part; inequality of the line of the spinous processes, with depression of the upper portion of the spine, and corresponding prominence of the lower. There is an inability to support the body in the erect position, and to move the spine in any way; hence, when the upper portion of the column is injured, the patient holds his head in a stiff and constrained attitude, fearing to turn it to either side.

The **General Symptoms** of fracture of the spine are dependent upon the injury which the cord has received. If the fracture have not implicated the spinal canal, as when only the tip of a spinous process has been broken off, or if it be unattended by displacement, although it may traverse the body and arches, no symptoms depending upon injury of the cord need exist. But even in these cases there is usually some paralysis, owing perhaps to the concussion to which the cord has been subjected at the moment of injury; and occasionally a sudden movement by the patient will bring on displacement, by which the cord is compressed and all the parts below the injured spot are paralysed. A woman was admitted into University College Hospital with an injury of the neck, the nature of which could not be accurately ascertained. She was in no way paralysed, but kept her head immovable in one position. A few days after admission, whilst making a movement in bed, by which she turned her head, she fell back dead. On examination, it was found that the spinous process of the fifth cervical vertebra had been broken off short, and was impacted in such a way between the arches of this and the fourth as to compress the cord. This impaction and consequent compression probably occurred at the time of the incautious movement, thus producing immediate death. When there is only partial displacement, there may be but incomplete paralysis of the parts below the injury; of one arm, one leg, &c. In these cases there is usually great pain at the seat of fracture, and extending from it along the line of junction between the paralysed and sound parts round the body or along the limb. This symptom, which is of great importance as exactly defining the seat of injury, is due, as I found in dissecting a case of fracture of the sixth cervical vertebra under my care, to the fractured bone compressing and irritating the nerve that issues from the vertebral notch opposite the seat of injury.

When the cord is implicated, the symptoms will vary according to the seat of the injury and the extent of the damage. For a detailed account of the symptoms presented by injuries of the different portions of the cord, the reader is referred to the section on "Wounds of the Spinal Cord" (p. 786).

If fracture of the spine be occasioned by indirect violence, as by the head being forcibly bent down on to the chest as the patient is driving under an archway, and a fracture be thus occasioned through the lower cervical or upper dorsal portion of the column, we shall find that the cord being lacerated, and compressed transversely in one part only, the ordinary symptoms of a division of the cord at that part will be presented, the patient being paralysed below the seat of injury; but the paralysed parts manifest signs of reflex irritability, the legs being drawn up when the soles are tickled. When the fracture is by direct violence, as by a heavy fall on the back from a height, the cord will be concussed as well as paralysed, and then no reflex phenomena are presented by the patient.

In a large proportion of cases of fracture of the spine, there is such displace-

ment of the bone as to compress the whole thickness of the cord, and thus to occasion complete paralysis of motion and sensation in the parts below the seat of injury. This paralysis resembles that which arises from simple division of the cord, but is followed by greater impairment of nutrition, as shown in wasting, cachexy, and a tendency to sloughing. The reason of this difference is, that in fracture the cord is not simply compressed or divided, but is continuously irritated by the edges of broken bone, and thus not only becomes incapable of healing, but is kept in a state of chronic irritation and inflammation. If the fracture be above the origin of the phrenic nerve, respiration will be arrested and the patient die instantaneously.

Prognosis.—The danger from fracture of the spine depends on the amount

Fig. 329.—Fracture through the lower dorsal and first lumbar vertebræ, with displacement backwards of upper fragment.

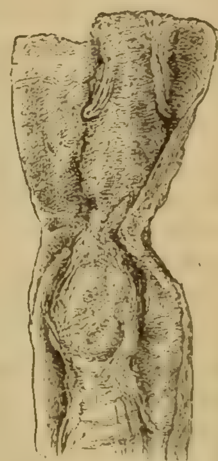


Fig. 330.—Crush of Cord and its membranes. The result of a Fracture of the Spine.

of injury sustained by the cord, and the situation of that injury. Thus, if there is no displacement of the broken vertebra or injury to the cord, union will take place, and the patient recover perfectly ; but fractures of the spine through the bodies of the vertebræ, with displacement and compression of the cord, are most commonly fatal.

When the fracture occurs in the middle or lower dorsal regions, so that the lower portion only of the cord is injured, the patient may live for many years, even though the cord is completely severed and the spinal canal obliterated by the displacement, and by the new bone formed in the process of repair. There is a specimen in University College Museum which well illustrates this fact (Fig. 329). The patient was a man thirty-two years of age, who fell fifty feet from a tree. He sustained a fracture of the spine, with the unusual displacement of the upper fragment backwards. The fracture became firmly consolidated, and he lived for nine and a-half years afterwards, completely paralysed below the middle of his body. There was no sloughing of the hips or back, and blisters, which were for some reason applied to the paralysed parts, are stated to have healed without difficulty. He suffered from repeated attacks of cystitis, in one of which extension took place to the kidney, and he died of

pyelo-nephritis. The specimen shows ossification of the dura mater below the seat of fracture.

Even when the injury is in the cervical region, recovery may take place, although the case may appear most unpromising. I have known at least four cases in which recovery has taken place after fracture of the lower cervical vertebra, with paralysis more or less complete from the neck downwards. In one of these cases where the neck was broken by a fall in kangaroo-hunting, the patient, young and active, after being paralysed for eleven months, made a fair though not complete recovery—some paralysis, with wasting, of the extensors of the hands being left.

When death takes place, it may occur in three different ways. It happens primarily as the immediate result of the injury, in all those cases in which the fracture is above the origin of the phrenic nerve. It occurs secondarily and indirectly, at a more or less remote period, as the result of changes in the body dependent on permanent separation of the parts below the injury from the nervous centres above. At the seat of injury, compression, or crushing, inflammation is necessarily developed ; thence it spreads along the membranes, giving rise to effusion into the canal, and into the cord itself, causing softening. It is, doubtless, by the gradual extension upwards of this secondary inflammatory softening, that death is ultimately occasioned in many cases. Thus, an injury in the cervical region, which was not immediately fatal, may ultimately prove so by extension of the mischief to the origins of the phrenic nerves, and so arresting respiration. Many also perish from bedsores and a very large proportion prove fatal from pyelo-nephritis secondary to cystitis, with decomposition of the urine.

The **Treatment** is simple enough in those cases in which the patient escapes without implication of the cord. It is evident that in such cases no attempt at reduction should be made, lest by dislodgment of the fragments the cord might be injured. The patient must be placed flat upon his back, and the strictest possible rest maintained. König of Gottingen has recommended, in cases of fracture in the dorsal or lumbar region without damage to the cord, that Sayre's plaster-of-Paris jacket should be applied at as early a period in the case as possible. He has himself applied it as early as the fourth day, and Berkeley Hill at the end of thirty hours. In these cases the patient was suspended by the arm-pits, and at the same time supported by assistants, care being taken not to lift him sufficiently high to raise the feet from the ground. Extension under these circumstances, however, cannot be devoid of danger, and the better plan would be to apply the apparatus in the way recommended by Walker of Peterborough. He first applies a flannel vest without sleeves, or if there is any difficulty in putting this on, a piece of soft flannel wide enough to reach from the axillæ to the hip may be passed under the back, and carefully sewn down the front, so as to leave no creases. A number of strips of muslin-bandage, cut of the proper length to encircle the body, and to overlap for a few inches, are then prepared. These are dipped in a mixture of plaster-of-Paris, 1 lb., water, ℥viij, with ℥j of mucilage of gum acacia added, to delay the setting. They are then quickly spread on a bed covered by a mackintosh-sheet, each overlapping that above for two-thirds of its width. They must be thus arranged till a sufficient width is reached to extend from the patient's axillæ to midway between the crest of the ilium and the trochanter ; and sufficient number of strips should be used

to make the whole about six layers thick. The patient is then carefully lifted and laid on the bandages, which are folded over and rubbed smooth, as in an ordinary plaster-of-Paris bandage. A pad should be put over the epigastrium, which can be withdrawn when the splint is firm. In the cases recorded by König, and in Hill's case the results were most satisfactory. Two cases have, however, been recorded, in which the patient could not bear the bandage, but no harm was done by the attempt to use it.

Another plan of treatment, originally recommended by Wormald, is to raise the patient carefully up, and place beneath him a large sheet of softened gutta-percha, and so to mould a splint to the back.

In *cases in which the cord is injured*, attempts at the reduction of the fractured and displaced spine must not be lightly undertaken. It may prove unsuccessful, greatly increase the sufferings of the patient, or hasten his death. In cases of injury to the lower cervical vertebræ, it would rarely, if ever, be proper to make such attempts. In the upper and middle dorsal they would not be likely to succeed, owing to the want of mobility of this part of the column. In the lower dorsal and lumbar regions they would be less dangerous, and more likely to prove advantageous.

Fig. 331.—Apparatus for Fracture of the Spine.

All our efforts must be directed to prolonging life, if the fracture be in such a situation (at any point below the upper dorsal vertebræ) as to hold out a prospect of continuance of life for a few weeks or months. Means must be taken to prevent the occurrence of sloughing of the nates, an accident that is commonly fatal in these cases. The patient should be laid at once on a water-bed, cushion, or mattress, and must be kept scrupulously clean. If possible, a mattress should be obtained, with a segment that will pull out to admit the bed-pan, or some such arrangement to avoid disturbance of the spine. Every precaution should be taken to prevent the supervention of cystitis. For this purpose the urine must be drawn off by a catheter, regularly, at least twice in the day. The catheter should be dipped in a vessel containing a 1-in-20 solution of carbolic acid before being used, and oiled with carbolic oil (1 in 10). If, in spite of these precautions, ammoniacal decomposition of the urine should take place, the bladder must be washed out with an antiseptic solution every time the water is drawn off. Solution of permanganate of potash, or three grains of quinine, with three minims of dilute sulphuric acid to the ounce of water, will be found the most efficient preparations. (See Cystitis.) If, as usually happens after a time, the bowels become confined, relief must be afforded by castor-oil or turpentine enemata. A nourishing diet must be administered and perfect rest in one position enjoined. In this way life may be maintained for a considerable length of time, and bony union of the fracture may sometimes take place, though the patient may not recover from the paralysis, and may die eventually from disease of the cord. But in some cases a much more satisfactory result is obtained; the patient gradually gains power in the paralysed parts. In these cases much assistance will be afforded him by wearing, as soon as the fracture is sufficiently consolidated, the apparatus shown in Fig. 331, consisting of a firm pelvic band, with a strong iron rod shaped to the spine, and running as

high as the vertex, having padded transverse arms to support the head and shoulders, and the whole attached to a stout leather-case moulded to the back and shoulders. Sayre's plaster-of-Paris jacket may be advantageously employed at a later stage when the patient is able to bear suspension.

Trephining the Spine.—As the fatal result of fracture of the spine, with compression of the cord by the broken vertebra, or by extravasated blood, is almost inevitable, the idea has naturally suggested itself to Surgeons that life might be prolonged, and health perhaps restored, if the same operation were extended to the spine which is successfully employed in parallel cases of injury of the head; viz., the elevation and removal, if necessary, of the depressed portion of bone. This operation, originally proposed by Heister, was first performed by Louis and Cline. It may be done as follows. The patient lying on his face, a free incision, several inches in length, from three to five, according to the extent of the injury, is made along the line of the spinous processes, and the muscular masses on each side of the spine are dissected away, so as to expose the osseous surfaces. The spinous processes, at the seat of injury, should then be successively seized with strong forceps, and gently but firmly moved, in order to see whether there be fracture at their base or supporting arches. If a portion of bone be completely broken off, it may, after all ligamentous connections have been severed, be raised by the forceps or an elevator. Should one arch only be broken through, the uninjured one may be divided by cutting pliers or a Hey's saw; or, should both be unbroken, the Surgeon may, if he think it prudent to proceed further, divide both in this way, and so remove them and the spinous processes, and expose the theca of the cord. After the operation, the patient is to be kept in the prone position.

The results of this operation are not very encouraging. It has been performed by various Surgeons in different countries, but chiefly in America, about thirty times; and, although some temporary advantage seems to have occurred in a few of the cases, permanent recovery has resulted only in one instance—by Gordon of Whitworth Hospital, Dublin; but even in this case the paralysis remained. But, though so far the result has been but little satisfactory, ought Surgeons to discard the operation? I think not; because, as fracture of the spine with serious lesion of the cord cannot be recovered from, and has an almost invariably fatal termination, and as the evil consequences of the fracture are dependent not only upon the primary lesion of the cord, but on the secondary inflammatory processes set up in it by the continued irritation of the fractured fragments, we are justified in attempting the removal of this source of certain misery and impending death by the only means in our power—operative procedure: and we are the more justified in this course, as the operation is not necessarily dangerous, does not appear often to have hastened death, and has certainly, in some cases, afforded relief, the paralytic symptoms disappearing to a great extent, and the patient being able to move limbs that were previously motionless.

One serious objection that has been urged against the operation must not, however, be overlooked. It is, that in the great majority of cases the fracture of a vertebra is through the body and not through the arches. This undoubtedly is so, and it is this circumstance that has rendered the operation as yet little more than a means of giving relief when the cord is partially divided and lacerated by being stretched over a rough and jagged edge of the broken

body of a vertebra thrust back against it. Little more than temporary relief can be expected from the removal of the pressure from behind by cutting away the arches. But, when these portions only of the spinal column are fractured and displaced—a rare condition it is true—then permanent good may be expected to follow the operation. If signs of such injury exist, as evidenced by distortion or depression of one or more spinous processes, it would most certainly be quite proper for the Surgeon to adopt the only means in his power of affording relief. The principal danger, and usual cause of death after cutting away a portion of the spine is either the continuance of the inflammation excited by the injury in the cord and its membranes, or its increase or production by the operation itself.

Dislocations of the Spine.—On looking at the arrangement of the articular surfaces of the vertebræ, the very limited motion of which they are susceptible, and the way in which they are closely knit together by strong ligaments and short and powerful muscles, it is obvious that dislocations of

Fig. 332.—Dislocation between the Fifth and Sixth Cervical Vertebræ.

Fig. 333.—Dislocation of the Axis from the Third Cervical Vertebra.

these bones must be excessively rare. So seldom, indeed, do they occur that their existence has been denied by many Surgeons. Yet there are a sufficient number of instances on record to prove that such accidents may happen. The cases that have been met with have usually been associated with partial fracture, but this complication is not necessary. In all, the displacement was incomplete ; and, indeed, a complete dislocation cannot occur. Fracture may occur anywhere in the spine, but dislocation without, or with very slight, fracture is met with only in certain situations. Dislocation of the spine may occur in the following parts. 1. Between the occiput and atlas. This is very rare. 2. Between the atlas and axis. This, though rare, is much less so than the preceding, and may occur with or without fracture of the odontoid process ; and when the odontoid process is broken, death at once ensues. 3. Dislocation between the second and third cervical vertebræ is very rare—as rare as dislocation between the atlas and axis. 4. Dislocation generally happens some-

where between the fifth and seventh cervical vertebræ. Dislocation without fracture can scarcely occur in the dorsal region, and there is no recorded case of a pure dislocation in the lumbar region.

In Fig. 332 we have an instance of dislocation of the fifth from the sixth cervical vertebra, with the separation only of a scale of bone which was adherent to the intervertebral fibro-cartilage. The patient had fallen on his head from a van and died of asphyxia in twenty-four hours.

The spine may be so seriously injured that dislocation is at any moment imminent, and yet the patient may live for some days before the displacement occurs, by which the cord is compressed. A man was admitted into University College Hospital, who had been crushed by falling between the platform and a train in motion. Amongst other severe injuries he had paralysis of the circumflex and musculo-spiral nerves of the left arm, but no hyperæsthesia. On the third day, whilst being moved in bed, his head fell to one side, and he suddenly died. On examination after death, it was found that the second cervical vertebra, carrying the atlas and head with it, had been dislocated from the third (Fig. 333); the connecting ligaments being completely torn through on the left side, so that the head falling to one side had caused fatal compression of the cord.

Dislocation of the Occipital Bone from the Atlas has been described in two instances only—by Lassus and by Paletta. In the case by Lassus, death ensued in six hours, and the right vertebral artery was found to be ruptured. In the other case, the patient is said to have lived for five days, but the report is so incomplete that little value can be attached to it.

Dislocation of the Atlas from the Axis is of more frequent occurrence. It may happen with or without fracture of the odontoid process. In either case, the atlas is carried forwards and the spinal cord thus compressed. This accident is said to have been caused by a person in play lifting a child off the ground by its head; the combination of rotation and traction in this movement being especially liable to occasion the accident. For the same reason, it has been met with in those who have been executed by hanging. Death would probably be instantaneous in these circumstances. It has, however, been stated that, in dislocations of this kind, life has been saved by the Surgeon placing his knees against the patient's shoulders, and drawing or twisting the head into position. This, however, I cannot believe possible if the displacement have been complete, as death must be instantaneous, the cases of supposed dislocation and reduction having probably been instances of concussion of the cord with sprain of the neck.

Dislocation of any one of the five Lower Cervical Vertebræ may occur. The third vertebra is least frequently dislocated; the fifth is more commonly displaced (Fig. 332). These injuries are usually associated with fracture; sometimes, though rarely, they happen without this complication. In these dislocations, as in those that have already been described, the displaced bone carries with it the whole of that portion of the vertebral column which is above it.

In dislocations, the articulations between the two vertebræ are torn open. The supraspinous and interspinous ligaments, the ligamenta subflava, and the common posterior ligament, are torn through, so that the spinal canal is opened. The intervertebral fibro-cartilage may be torn, or it may be entire, a scale of the body of the subjacent vertebra being detached with it. When the spine

above the dislocated part is bent forwards, a wide gap is visible posteriorly, at the seat of injury.

Causes.—The causes of dislocation are numerous, and the following may be given as examples. A person standing in a cart and driving under an archway finds, too late, that he is too tall to clear the archway; he bends forwards, but, miscalculating the distance, his head is pressed violently downwards. A person takes a header into shallow water; his head comes against the bottom, is forcibly flexed, and his spine is broken or dislocated. Such accidents are not very unfrequent. I have seen several cases of paralysis, as well as of death, resulting from this kind of accident.

These accidents most commonly happen from forcible flexion of the neck though traction and rotation conjoined have occasioned them. In a case of luxation of the sixth and seventh cervical vertebræ, recorded by J. Roux, the accident happened to a sailor plunging into the sea for the purpose of bathing, and coming head foremost against a sail which had been spread out to prevent the attack of sharks; he died on the fourth day. In a patient of mine, who fell out of a window in such a way that the head was doubled forwards upon the chest, and who was brought to the Hospital with supposed fracture of the spine, we found after death, which occurred on the fifth day, that the seventh cervical vertebra, carrying with it the upper portion of the spine and the head, had been dislocated forwards from the first dorsal, of the intervertebral substance, detaching with it an extremely thin and small layer of bone from the body of the seventh vertebra. There was a wide gap posteriorly between the laminæ. There was no fracture about the articular processes, which were completely separated from one another. In the instance already referred to, in which a man fell on his head from a van, and death resulted in 24 hours, a similar displacement was found of the fifth from the sixth cervical vertebra, with compression of and hæmorrhage into the substance of the medulla, and disorganization of it to the extent of nearly an inch opposite the seat of dislocation, where it had been injured by the forward pressure of the dislocated vertebra.

In the **Dorsal Region**, dislocation of the spine, though excessively rare may occur; seldom, however, without being accompanied by fracture. The last dorsal vertebra has been several times found dislocated from the first lumbar with rupture of the intervertebral fibro-cartilage. In these cases, however, there has usually been found fracture of the transverse processes of the first lumbar vertebra, or, as in an instance recorded by Sir C. Bell, fracture of its body.

I am not acquainted with any case in which dislocation without fracture of the **Lumbar** spine has been observed.

The **Symptoms** presented by dislocation of the spine are, like those of fracture, dependent on the degree and seat of the injury inflicted on the spinal cord. And death will ensue at varying periods, according to whether the dislocation be above or below the origin of the phrenic nerves, in accordance with those rules that have been laid down at p. 786.

The **Diagnosis** between a dislocation and a fracture of the cervical spine is not easily made. But there is one symptom which, according as it is present or not, may throw much light on this point. It is the occurrence of pain, amounting to hyperæsthesia, along the line of junction between the paralysed and unparalysed parts. In fracture this will commonly be found to be present

(p. 791). In dislocation, where the nerves are not irritated or lacerated in their exit through the spinal column, it is absent.

The **Treatment** of dislocation of the spine resembles in all important respects that of Fracture of the vertebral column. *Reduction* has, however, been effected in a sufficient number of cases to justify the attempt being made when the danger is imminent.

Dislocation of the Transverse Process of the Cervical Vertebræ occasionally occurs. The patient, after a sudden movement, or a fall on the head, feels much pain and stiffness in the neck, the head being fixed immovably, and turned to the side opposite to that on which the displacement has occurred. In these cases I have known *Reduction* effected by the Surgeon placing his knees against the patient's shoulders, drawing on the head, and then turning it into position, the return being effected with a distinct snap.

Wound of the Theca Vertebralis.—Holmes has recorded two cases in which this accident happened from the stab of a penknife in the lumbar region, one of whom died. The only characteristic sign was the escape of cerebro-spinal fluid in large quantities from the wound.

CHAPTER XXVI.

INJURIES OF THE FACE AND ADJACENT PARTS.

Face.—Cuts about the *Cheeks and Forehead* are of common occurrence. These injuries present nothing peculiar, except that the structures of the face show the same ready disposition to repair that characterizes the scalp when injured.

In the *Treatment* of these wounds, it is of much consequence to have as little scarring as possible. The edges, after being well cleaned, should be brought neatly into apposition by fine hare-lip pins and twisted suture, or by one or more wire sutures deeply applied to take the chief strain, and a number of fine horsehair interrupted sutures to bring the edges in accurate apposition. If the wound penetrate to the nose or mouth, so that there will be sufficient drainage from the mucous surface, the skin may be covered with collodion.

When the wound is in the neighbourhood of the eyelids, especial care must be taken to prevent any loss of substance, lest the contraction of the cicatrix produce eversion of the lid. In those cases in which a portion of the nose or lip has been lost, much may be done to repair the deformity by properly conducted plastic operations, such as will be described in Chapter LVIII. The bleeding, which is usually very free in wounds of the face, in consequence of the division of some arterial branch, may often be arrested by passing the hare-lip pin under the vessel, and applying the twisted suture above it, so that it may be compressed.

If the *Lip be cut from within,* by being struck against the teeth, the coronary artery may be divided, the patient swallowing the blood that flows into the mouth. Some years ago, a man was brought to the Hospital, drunk, and much bruised about the face. Shortly after his admission he vomited a large quantity of blood, which was at first supposed to proceed from some internal injury : but, on examining his mouth, it was found that the blood came from the coronary artery of the lip, which was divided with the mucous membrane.

Parotid Duct.—It occasionally happens in wounds of the cheek that the parotid duct is divided, in consequence of which the wound does not close, and a trickling of saliva takes place upon the outside of the cheek ; a **Salivary Fistula**, a source of much disfigurement and inconvenience, being established. The surface surrounding it is puckered and somewhat excoriated, and the fistula opens by a granulating aperture.

If from its anatomical situation a wound is known to have divided the parotid duct, the formation of a fistula may be prevented by bringing the skin surface accurately together, leaving the mucous aspect of the wound freely open and covering the surface with a piece of lint dipped in collodion. If the divided ends of the duct can be seen in the wound it has been recommended to pass one end of a fine piece of silver wire down into the mouth and the other up the duct towards the parotid for a short distance and then through

the mucous membrane into the mouth; the two ends are then knotted together inside the mouth and the external wound closed. By this means the continuity of the duct is maintained while the wound heals, and at the end of a week the silver wire may be withdrawn by dividing the loop in the mouth. Should a fistula form it must be treated by the operation that will be described in Chapter LV.

Besides fistula of the Stenonian duct, other fistulous apertures may occur in the cheek, as the result of injury or disease, allowing the escape of a small quantity of saliva. These openings are always closed with difficulty: the edges becoming callous, and not readily taking on reparative action. Closure may be effected in some cases by cauterization with nitrate of silver, or with a red-hot wire, due attention being paid to the general health. In other cases, the electric cautery may prove successful. If, however, the opening be free, with much indurated structure about it, it may be necessary to excise a portion of the edges before bringing them together.

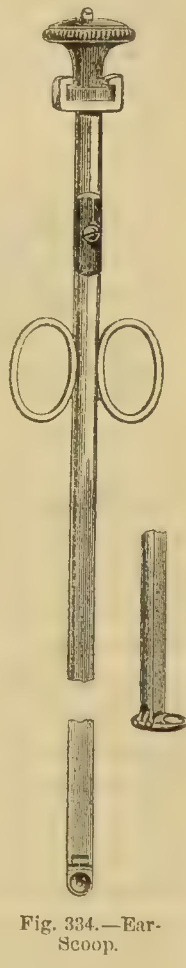


Fig. 334.—Ear-Scoop.

Nose.—**Foreign Bodies**, such as pebbles, beads, dried peas, &c., are occasionally met with in the nostrils of children, having been stuffed up in play and become so firmly fixed as to require extraction by the Surgeon. In most cases a bent probe or an ear-scoop will remove the impacted body most easily. If it be large and soft it may often be easily removed with a pair of forceps, but a hard smooth body is almost sure to be pushed further up with these instruments. It is always best to administer an anæsthetic, otherwise the involuntary movements of the child will greatly add to the difficulties of the Surgeon. If the body be not removed it may give rise to chronic purulent catarrh or even to disease of the bones.

The Ears are not unfrequently *wounded* in injuries of the head and scalp; a portion of the external ear being sometimes torn down and hanging over the side of the face. In these cases, as in scalp-injuries, the part should never be removed, but, however lacerated and contused, should be cleaned and replaced by means of a few points of suture. When the cartilaginous portion of the ear is divided, nice management is usually required in effecting perfect union.

Foreign Bodies are often pushed into the ears of children. When pointed or angular, such as pieces of stick, they may readily be extracted with forceps provided they can be clearly seen; but when round and small, such as pebbles or beads, they are not so easily removed.

The foreign body may occasionally be removed by passing the bent ear-scoop round it. In some cases I have found an instrument (Fig. 334) made by Coxeter on the model of Civiale's urethral scoop, useful in extracting a foreign body from the ear. It can be introduced straight and passed beyond the body, when, by the action of a screw in the handle, the scoop is curved forwards, and so enables extraction to be readily effected. But, as a rule, it is bad practice to attempt to remove foreign bodies from the ear by means of instruments: in the majority of cases the offending body is best removed by

forcibly syringing the ear with tepid water, injected by means of a large brass syringe in a full stream, the pinna being drawn up so as to straighten the external meatus. In this way the bead or pebble is soon washed out by the reflux of the water striking against the tympanum. It may be laid down as a good general rule, that if a round or oval body cannot be dislodged by syringing it will not be removed by instruments, and if the proper use of the syringe do not suffice, it is better to leave matters alone, and to allow the foreign body to become loosened when it can be easily syringed out, than to poke instruments into the ear with the view of forcibly extracting it. These attempts are ill-advised; and I have known death from inflammation and suppuration in the middle ear extending to the meninges of the brain, to follow from prolonged and unsuccessful efforts at the extraction of a pebble from the ear.

ORBIT.—**Injuries of the Orbit** may be dangerous, either to the brain or to the eye. If wounds be deep and directed upwards, they are always serious, on account of the proximity of the brain; thus a pointed body, such as a piece of stick, the end of an umbrella, or a knife thrust into the orbit, may perforate its superior wall, and produce a fatal wound of the brain. The injury to the brain through the orbital plate of the frontal bone may be fatal by the cerebral inflammation that is induced; or the thrust may extend deeply, and, lacerating the internal carotid artery, occasion fatal hæmorrhage. In one remarkable case recorded by Nélaton, a young man was wounded by the thrust of the point of an umbrella in the orbit; the cavernous sinus and internal carotid artery on the opposite side were wounded, an arterio-venous aneurism formed, the eyeball became prominent, and death from hæmorrhage eventually resulted from the giving way of the aneurism. Occasionally inflammation is set up in the loose fat of the orbit, giving rise to abscess which may point in either eyelid; or to inflammation which may extend to the membranes of the brain. In other cases, wounds of the orbit may be followed by loss of vision, without the eyeball being touched; either in consequence of injury of the optic nerve, or at a later period from the division of some of the other nerves of the orbit producing sympathetic amaurosis, as occasionally happens even from ordinary wounds of the face implicating some of the terminal branches of the fifth pair.

EYE.—**Injuries of the Conjunctiva.**—A foreign body under the lids on the surface of the conjunctiva gives rise, as every one knows, to the most intense and painful irritation, accompanied by injection of the conjunctival vessels, an increased flow of tears, and some swelling of the membrane. More severe effects are produced by lime; caustic fluids or heated metal produce more serious effects. If they actually destroy the epithelial surface adhesion may form between the lids, and opacity of the cornea, causing total blindness, may result.

In order to remove foreign bodies lodged between the ball and the eyelids, the latter must be everted so that the angle between the palpebral and the ocular conjunctiva may be properly examined. For this purpose the lower eyelid need only be drawn down, whilst the patient is directed to look up; but the eversion of the upper eyelid requires some skill. It is best effected by laying a probe horizontally across it, immediately above the tarsal cartilage; the Surgeon then, taking the eyelashes, in the middle of the lid, lightly between his finger and thumb, draws the eyelid downwards and forwards, at the same time that he everts it by pressing the probe firmly backwards

and downwards against the eyeball. The lid may also be everted without using a probe. The method of so doing is thus described by Streatfeild. The Surgeon, standing before the patient, places the end of his forefinger sideways on the lid near its outer edge, without involving any folds of loose skin ; and pressing a little on the eye, makes the lid slide downwards, as far as possible, over the lower lid. The lid (not the lashes) is then seized firmly by the end of the thumb applied sideways ; and the end of the forefinger is turned downwards, while the lid is held firmly by the thumb and finger. The lid is thus everted (Fig. 335). The little operation cannot, however, be always done the first time it is attempted. The patient may move back his head just as the turn is to be completed (therefore the head of the patient must be steadied by being placed against the wall, or the back of his chair, or by the other hand behind it) ; or the lid is not secured between the finger and thumb before the eversion is attempted ; or the lashes only and not the lid are held ; or one fears to press the forefinger sufficiently into the eye to effect the eversion. It is very much more difficult if the patient be fat, or the eye deeply set. When the lid is everted the patient should look down in order that the whole of the upper part of the conjunctiva, where the foreign body will probably be found, may be carefully examined. If it be dirt or lime that has to be removed, this is best done by a small scoop, after which the conjunctiva may be gently washed with a stream of water. A drop of olive- or castor-oil may then be put into the eye and the lids closed and covered with a pad of wet lint.

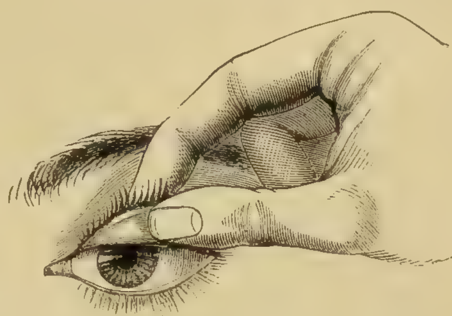


Fig. 335.—Eversion of Upper Lid for Detection of Foreign Bodies.

The conjunctiva may also be *lacerated* by scratches or contused by blows. These injuries are accompanied by extravasation of blood beneath the membrane. At the same time there is often extravasation into the skin of the lids. A "black eye" is best treated by the continuous application of a weak spirit lotion.

Injuries of the Eyeball are so commonly followed by impairment or total loss of vision, as to constitute a most important series of accidents ; the delicacy of the structure of this organ being such, that injury of it is often followed by complete opacity of the lens or other media and loss of sight. The impairment of vision may be the result of direct violence applied to the organ, injuring its more transparent parts or displacing the lens ; or it may arise indirectly from various causes which will be presently described.

The injuries of the eye produced by *direct violence*, may be divided into contusions and wounds.

Contusion of the Eyeball, without rupture or apparent superficial injury, may give rise to temporary or permanent blindness from hæmorrhage from the retina, due to the concussion. This condition is easily recognizable by the ophthalmoscope.

Contusions of the Eye with Rupture of some of the Structures of the Ball is a most serious accident. Most frequently the injury is internal, the outer tissues escaping injury. In this case we may have an extra-

vasation of blood into the eyeball, completely filling the anterior chamber, hiding and complicating the deeper mischief within the globe. In other cases there may be hæmorrhage into the vitreous body, with or without detachment of the retina. This condition, termed *hæmophthalmia*, is frequently associated with separation of the ciliary margin of the iris. In other cases, the crystalline lens may be driven backwards into the vitreous humour, or forwards into the pupillary aperture, or the anterior chamber. In more severe contusions the cornea may be ruptured, or, more commonly, the sclerotic gives way, the vitreous body escaping, and vision being permanently destroyed. In some rare cases, the lens is displaced through a rent in the sclerotic, and lies under the conjunctiva. The exact nature of all these injuries is necessarily more or less concealed at first by the extravasated blood. As a consequence of such injuries, the eye usually becomes inflamed, with intense frontal and circum-orbital pain ; disorganization of the ball ultimately ensuing.

The *Treatment* of these accidents varies with the degree of injury. Perfect rest of the eye is essential ; for this purpose, both eyes must be closed for four or five days, after which it may suffice to close the injured eye only. If the globe is not ruptured, all that can be done is to apply a pad of wet lint over the eye, and leave the cure as far as possible to nature. The patient should be kept quiet and on moderate diet. If there be much pain, a few leeches may be applied to the temple, but the repeated general blood-letting and the free administration of calomel and opium, formerly recommended, are now universally recognized as being not only useless, but positively injurious. The bowels must be regulated by the administration of purgatives when necessary. In some cases opaque masses and bands of adhesions will be formed in the anterior chamber or the pupillary aperture, preventing the entry of light more or less completely. If the lens be displaced it should be left till the early inflammation has subsided. If it be in the anterior chamber, it may require removal, and the same may be necessary should it become opaque at a later period, even if it have not been displaced. If the cornea or sclerotic be ruptured, any protruding iris or choroid must be replaced if possible, and the eye closed and covered with a pad of wet boracic acid lint, which must be frequently changed. The injury is often followed by inflammation and suppuration of the eyeball, necessitating removal of the globe.

Wounds of the Eyeball may be divided into those that are merely superficial, and do not penetrate into its chambers ; and those that perforate its coats.

Non-penetrating Wounds.—Superficial abrasions of the cornea or wounds raising a small flap of its epithelial covering, such as may sometimes be inflicted by scratches of the eyeball with the nails of children, are extremely painful and troublesome. Splinters of iron, or other metallic bodies, often become fixed in the cornea, and cause constant irritation till they are removed.

In the *Treatment* of these superficial injuries, the first point is to ascertain whether the symptoms are due to a simple abrasion or to the lodgment of a foreign body. If it be a simple abrasion, the symptoms will be at once greatly relieved by putting a drop of castor-oil in the eye. If a foreign body be detected, it must at once be removed. If it be fixed in the cornea, as commonly happens, it may be picked off with the point of a lancet or cataract-needle, or a "spud." If it be a fragment of iron, it can often be easily removed by means of a common magnet ; but if it be more deeply imbedded,

the plan successfully adopted by McHardy of employing an extremely powerful electro-magnet, will be found very efficacious. It is well to bear in mind that a splinter of iron often leaves a small brown stain, which, however, usually disappears in the course of a few days.

Penetrating Wounds of the Eyeball present great variety; they may be incised, as those inflicted by bits of glass, or knives, or they may be punctured, as by bits of sharp stick, or steel pens, or they may be made, as not unfrequently happens during the shooting season, by the lodgment of stray shot. In iron works, small splinters of metal not unfrequently penetrate the cornea. In all cases these accidents are highly dangerous to vision, but this is especially the case if the foreign body lodge in a part of the eye from which it cannot be extracted; sight is then usually lost. The danger of incised wounds usually arises either from the eye being opened to such an extent that the humours escape, or else that, the iris becoming engaged in a wound of the cornea, a hernial prolapse of it occurs. The more remote effects arise from the occurrence of inflammation and suppuration extending to the whole globe, leading to complete disorganization of the eyeball; or supposing this be avoided, there may be an opaque cicatrix in the cornea, or opacity of the lens or its capsule; or else adhesions may form, stretching across the pupil and adhering to the capsule of the lens, or between the iris and the cornea.

The *Treatment* of penetrating wounds must be conducted on the same principles as rupture of the coats. If the iris have protruded through a wound in the cornea, it should be carefully pushed back, and a drop or two of the solution of atropine put upon the eye. If it cannot be returned, it may be removed with a pair of fine curved scissors (Fig. 340); and, at a later period, any staphylomatous tumour that may form should be touched repeatedly with a pointed piece of nitrate of silver. In clean wounds extending into the sclerotic, it may be necessary to introduce a fine silk suture. If the lens or its capsule have become opaque, thus forming traumatic cataract, extraction may be required at a later period of the case.

If the eye be so extensively opened or deeply injured that vision is irreparably lost, and extensive suppurative inflammation in it and in the structures of the orbit is threatened, the sooner the globe is extirpated the better; the patient being thus saved much local and constitutional disturbance, and the danger of sympathetic affection of the other eye being diminished.

Indirect Injury of the Eye often follows injuries of the nervous system. Thus impairment of vision may be produced by concussion of the eye-ball through blows on the head; by injuries of the face implicating the fifth pair of nerves; by injury of the spine; or by injury of the sympathetic.

Concussion of the Eye may be produced by a direct blow on the organ; or it may be the result of a blow on some other part of the head or face. In the latter case, the injury is dependent on the transmission of the force through the bones of the head or face to the structures within the orbit. The resulting impairment of vision is at its worst at the moment of the injury, and either slowly disappears, or becomes permanent in consequence of the development of structural changes in the eye. That indirect violence may produce serious lesion of the eye, is evident from the fact that the lens has been in this way dislocated without any direct injury having been inflicted on the eye itself. Deyber relates a case in which cataract was induced by a wound of the eyebrow from a stone, the eye itself being otherwise uninjured: and I have

seen cataract occur in an otherwise healthy woman aged 40, three or four months after the receipt of a blow on the malar bone in a railway collision. It also often happens that, in cases of a general shock to the system, obscuration and impairment of vision gradually manifest themselves. (See p. 776 *et seq.*)

When impairment of vision remains permanent, or is gradually developed, after concussion, it is due to interference with the nutrition of the structures of the eye. In such cases, atrophy of the optic disc may often be discovered by ophthalmoscopic examination. The development of cataract after blows on the eyebrow or cheek is to be accounted for by the frontal or infraorbital branches of the fifth nerve being implicated and irritated, so as to impair the nutrition of the globe.

The eye may suffer also in consequence of **Wound or Irritation of the Branches of the Fifth Pair of Nerves**.* This has long been observed. Hippocrates speaks of loss of vision consequent on wounds of the eyebrow; and makes the very accurate observation, that the impairment is less when the wound is recent, but increases as cicatrization advances. Fabricius Hildanus and La Motte relate cases in which blindness followed wounds of the outer angle of the orbit. Morgagni relates the case of a lady who, in consequence of the overturning of a carriage, was wounded by some splinters of glass in the upper eyelid. The eyeball was uninjured: but vision became gradually impaired, and was almost lost by the fortieth day after the accident.

It is by no means necessary for the production of impaired vision after injury of parts of the fifth nerve, that there should be an actual wound: a simple contusion is sufficient. Wardrop states that it is only where the frontal nerve is wounded or injured and not divided, that amaurosis takes place. Indeed, in some cases, amaurosis has been cured by division of the nerve after its partial injury. That it is the irritation, and not complete division of the nerve, that leads to loss of vision, is in accordance with the view of Brown-Séquard, that the immediate effects of section of a nerve are very different from those which are observed as the result of its irritation.

The loss of vision may come on instantaneously, as in a case related by Wardrop of a sailor struck by a ramrod on the eyebrow; after a few days, as in a case recorded by Chelius where the loss of vision came on eight days after a blow in the eyebrow; or after a longer lapse of time, as in most of the recorded cases. In the great majority of cases the impairment of vision is at first slight, and gradually goes on to complete loss of sight.

In what way can irritation of a branch of the trifacial nerve, unaccompanied by any direct injury of the eyeball or the structures of the orbit, produce instantaneously or remotely loss of vision? Some observers have attributed this to the propagation of irritation along the sheath of the nerve to the trunk of the ophthalmic division. But there is no evidence of such a propagation; and this explanation would not account for those cases in which blindness suddenly supervened. That injury of the fifth nerve produces important changes in the eye, has been incontestably determined in late years by the experiments of Snellen, Schiff, Büttner, Messner, and others; and whether we explain the morbid changes that occur in the eye as a consequence of the injury of the nerve by the supposition that "neuro-paralytic" inflammation is set up in

* See "Concussion of Spine," Lecture X., p. 233, *et seq.*, Longmans, 1882, for a full account of these injuries.

the globe, or suppose that the surface by losing its sensibility becomes more liable to the action of external irritants, matters little to the practical Surgeon.

Wardrop says that "the distribution of the first branch of the fifth pair or ophthalmic branch explains how wounds of the frontal, infra-orbital, and other branches of nerves which form anastomoses with the ophthalmic ganglion, are sometimes followed by amaurosis." No doubt it is to the intimate connexions that exist between the frontal nerve, the ophthalmic division of the fifth, and the sympathetic and ciliary nerves, that we must refer these various morbid phenomena resulting from its irritation. In what way this irritation of the frontal nerve exercises an injurious influence is doubtful, but the fact, as the result of clinical observation, remains certain, that in some cases it is the primary and determining cause of loss of vision.

Excision of the Eyeball.—This operation is thus performed. The

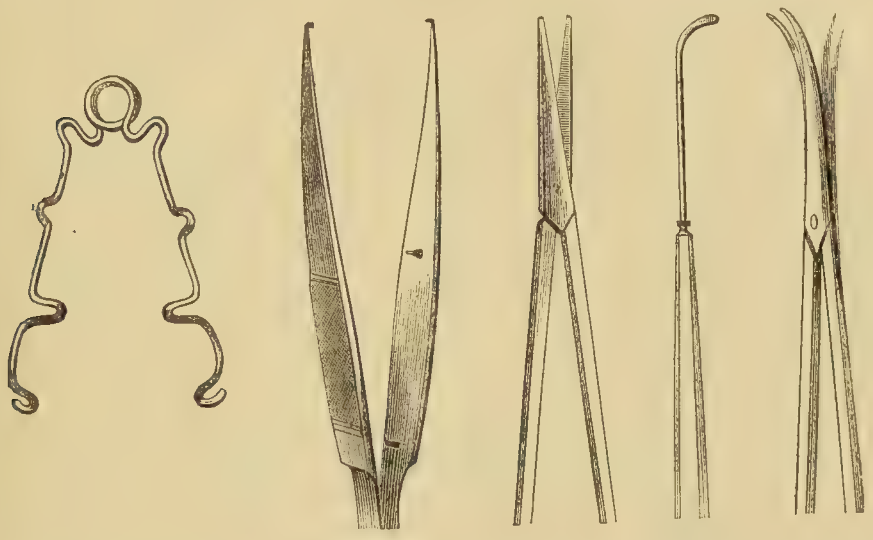


Fig. 336. Fig. 337. Fig. 338. Fig. 339. Fig. 340.

Fig. 336.—Wire-Speculum. Fig. 337.—Toothed Forceps with Fine Points. Fig. 338.—Straight Scissors. Fig. 339.—Strabismus-Hook. Fig. 340.—Scissors for Dividing Optic Nerve in Extirpation of the Eye.

patient being under the influence of an anæsthetic, an eye-speculum (Fig. 336) is introduced; the conjunctiva is then seized with a pair of toothed forceps (Fig. 337) as close to the margin of the cornea as possible, and a small opening made through it by means of a rather blunt-pointed pair of scissors (Fig. 338). The membrane is then divided circularly, always keeping close to the corneal margin. The squint-hook (Fig. 339) is then passed beneath the tendon of one of the rectus muscles, which is raised and divided, by the scissors passed between the hook and the sclerotic. The three other rectus muscles are then divided in order in the same way. The oblique muscles need not be separately searched for, and will be divided with the recti. The eyeball is then drawn forwards, and the ciliary vessels and nerves passing into it may be divided with curved scissors (Fig. 340), until the globe is attached solely by the optic nerve; lastly this is cut through from the inner side with the curved scissors. The speculum being still retained between the lids, a stream of cold carbolic acid lotion (1 in 40) is allowed to drop slowly from a sponge into the cavity of the orbit, by which all bleeding

is speedily arrested. Streatfeild recommends that a small round sponge squeezed out of the carbolic lotion, and compressed to make it go between the lids and a little way into the orbit, should be applied and kept firmly in position by a linen bandage. This will prevent any oozing of blood, and may be removed at the end of a few hours. It is then removed and the lids allowed to close, wet boracic acid lint, or lint moistened with any other antiseptic lotion, being applied over them till the stump of the eye is healed. Septic inflammation in the fat of the orbit is the only accident likely to occur after the operation, and this is scarcely likely to occur if ordinary cleanliness is attended to, and care be taken that the lids do not become glued together by dried discharges in such a way that decomposing matter can accumulate behind them.

Mouth.—Wounds of the mouth are seldom met with, except as the result of gunshot-violence. The amount of injury done to the soft structures, however great, is usually only secondary to the mischief that results to the brain, spinal cord, jaws, and skull, and must of course be treated on the ordinary principles of treatment of gun-shot and lacerated wounds.

Tongue.—Wounds of the tongue usually occur from its tip or sides being caught between the teeth during an epileptic fit. They have been known to be inflicted by insane patients, in attempts to excise or to bite off this organ. Should the hæmorrhage be free, the application of a ligature, or even of the actual cautery, may be needed. These wounds generally assume a sloughy appearance for a few days ; they then clean up, and granulate healthily. It is useless to bring the edges together by sutures, which readily cut out. If, however, a large portion of the tip be nearly detached, it must be supported in this way ; but the threads should be thick and passed deeply. Pieces of tobacco-pipe are occasionally driven into and broken off in the substance of the tongue, and they either give rise to very free hæmorrhage, or the wound may close and heal over the foreign body, the existence of which may not be known to the patient. In a case of this kind, where a man complained of much pain and stiffness in the tongue, with difficulty in deglutition, I found on examination, a hard swelling towards the base of the organ ; and on cutting down upon this extracted three inches of the stem of a clay tobacco-pipe, which had been lodged there for several months.

The Palate and the Pharynx are sometimes lacerated by gunshot-injuries of the mouth : or the wound may result from something that the patient happens to have between his lips being driven forcibly backwards into his mouth. Thus, a tobacco-pipe may, by a blow on the face, be driven deeply into the substance of the tonsil, or perhaps into the pharynx, wounding and lodging behind the arches of the palate ; it generally breaks off short, and the fragment that is left in gives rise to abscess, to ulceration of vessels, and perhaps to fatal secondary hæmorrhage. In a case that was under my care some time ago, the soft palate was nearly detached from the palate bones by a deep transverse wound, caused by the end of a spoon being forcibly driven into the mouth ; good union took place eventually, the part having been stitched together by a few points of suture. In some rare cases the internal carotid has been wounded from inside the mouth.

CHAPTER XXVII.

INJURIES OF THE THROAT: AND ASPHYXIA.

INJURIES OF THE LARYNX AND TRACHEA.

Fracture of the Cartilages of the Larynx.—The cartilages of the larynx may be broken and displaced by violent blows or by a squeeze, the fracture in some cases taking place transversely, in others longitudinally. Digital examination will at once detect the nature of the injury. In these injuries there is superficial extravasation of blood, with pain and difficulty in breathing, speaking, and swallowing. In some cases there is spitting of blood with cough. Fracture of the larynx is an extremely dangerous injury. Durham has collected 69 cases of which 53 died. The great danger is from asphyxia, which may occur immediately as a direct consequence of the displacement due to the fracture, or may come on at a later period as the result of inflammatory swelling. In some recorded cases, simple concussion of the larynx without fracture has been known to prove fatal, apparently from shock. Should symptoms of serious dyspnœa appear tracheotomy must be performed without delay; if not attention to position and support of the injured parts will suffice.

Wounds of the Throat.—These are of great frequency and importance, implicating as they do, some of the most important organs in the body. They may be divided into three categories :—

1. Those that do not extend into the Air- or Food-passages.
2. Those that implicate the Air-passage, with or without injury of the Œsophagus.
3. Those that are accompanied by injury of the Spinal Cord.

All these injuries are most commonly suicidal, and may be inflicted with every variety of cutting instrument; except where the spinal cord is injured, which must, in cases of suicide, be the result of gunshot-wound, and is necessarily fatal. Though incised, they are often jagged, and partake somewhat of the character of lacerated wounds, with great gaping of the edges.

1. **Wounds not extending into the Air- or Food-passages.**—In these wounds, there is very commonly free and even fatal hæmorrhage, and this sometimes though none of the larger arterial or venous trunks have been divided; the blood flowing abundantly from the venous plexuses or from the thyroid body when the wound is low down. If the larger arteries be touched, as the carotid and its primary branches, the hæmorrhage may be so abundant as to give rise to almost instantaneous death. Another source of danger in these cases proceeds from the admission of air into the veins of the so-called "dangerous region" of the neck. For this a free wound is by no means necessary, as is instanced by a remarkable case that occurred some years ago near London, in which the introduction of a seton into the fore part of the neck was followed by death from this cause.

Wounds of the internal jugular vein are necessarily very dangerous. There is not only the ordinary risk of primary hæmorrhage from a vessel of such large size, but the special danger of the introduction of air into it; should these evils be safely got over, the secondary ones of recurrent hæmorrhage, diffuse inflammation, and pyæmia, may yet have to be encountered. Ligature of the vessel above and below the wound in it, exactly as if it were an artery that had been opened, is the only course that can be safely pursued, unless the opening be very small, when it may be picked up and tied without occluding the lumen of the vessel. In one case, I saw and heard air enter the vein as it was being raised for the passage of the ligature, but the patient made a quick recovery.

The large nerves, such as the vagus and phrenic, can scarcely, in a suicidal wound, be divided without injury to the neighbouring vessels, but they may be injured by stabs or gun-shot wounds. The division, however, of the respiratory nerves on one side only, or even of one of them, would in all probability be fatal in man, by interfering with the proper performance of the respiratory act. In a case with which I am acquainted, where the phrenic nerve was divided during ligature of the subclavian artery, death resulted in a few days from congestion of the lungs.

In the **Treatment** of wounds of the neck of this category, the principal points to be attended to are, in the first place, the arrest of hæmorrhage by the ligature of all bleeding vessels, whether arterial or venous; and, secondly, bringing together the lips of the wound. If the cut be longitudinal, this may be done by strips of plaster; if transverse, by a few points of suture and by position, the head being fixed, with the chin almost touching the sternum, and retained in this posture by tapes passing from a nightcap to a piece of bandage fixed round the chest. I have had under my care one case in which, owing to the projection and mobility of the larynx, the wound did not unite, a large and deep gap being left, which required a series of plastic operations in order to effect its closure.

2. **Wounds implicating the Air-passage.**—Wound of the air-passage is common, and is revealed in suicidal attempts by the air being heard and seen to bubble in and out of the wound during respiration. These wounds vary much in extent, from a small puncture with the point of a penknife to a cut extending completely across the throat, and even notching the vertebræ. They are frequently complicated with injuries of the larger vessels and nerves, and sometimes with wound of the œsophagus. Most commonly the cut is made high up in the neck; for the suicide, thinking that it is the opening into the air-passage that destroys life, draws the razor across that part of the throat where this is most prominent and easily reached; and thus, through not wounding the larger vessels, which are saved by the projection of the larynx, frequently fails in accomplishing his object.

These wounds occur in four situations: above the Hyoid Bone; in the Thyro-hyoid Space; through the Larynx; and through the Trachea.

The wound may be made **above the Hyoid Bone**, the cut extending into the mouth and wounding the root of the tongue. A wound in this situation is usually attended with much hæmorrhage; and there is great trouble in feeding the patient, as the power of swallowing is completely lost.

The wound may be inflicted in the **Thyro-hyoid Space**, laying the pharynx open, but being altogether above the larynx. This is the most common situation

for suicidal attempts. In many cases, the incision is carried so low as to shave off or partly to detach the epiglottis and the folds of mucous membrane around it. In other cases, the edges of the glottis or the arytænoid cartilages are injured, the cut extending back to the bodies of the vertebræ. Here also there are great difficulty in swallowing and great risk of the sudden supervention of œdema of the glottis, and consequent suffocation.

When the **Larynx** is wounded the incision is usually transverse ; but I have seen a longitudinal cut made through the larynx, so as to split the thyroid and cricoid cartilages perpendicularly. In these cases of wounded larynx, there is much danger of the blood from the superficial parts trickling into the air-passage and asphyxiating the patient, and of inflammation of the bronchi and lungs supervening at a later period.

Wounds of the **Trachea** are not so common as those of the larynx, from which they differ but little in the attendant dangers.

The **Œsophagus** is seldom wounded, and such wounds still more rarely come under the care of the Surgeon, as it can be reached only through the trachea by a deep cut, which will probably implicate the large vessels.

Effects.—There are various sources of danger in wounds of the neck implicating the air-passage. The *hæmorrhage*, whether it proceed from any of the larger trunks, or consist of general oozing from a vascular surface, may prove either directly fatal by the amount of blood lost, or indirectly in consequence of the blood trickling into the air-tube, and accumulating in its smaller divisions, producing suffocation.

Asphyxia may supervene, either in the way already mentioned, or, when the wound has been inflicted above the larynx, from the occurrence of œdema of the glottis. It may likewise occur when the external opening is very small, and occasionally happens suddenly when the wound is nearly closed.

Another source of danger is the *loss of the natural sensibility of the glottis*, in consequence of which it no longer contracts on the application of a stimulus. Hence food taken in by the mouth may pass into the larynx and appear at the external wound, even though neither the pharynx nor the œsophagus has been wounded. This I have observed in many cases of cut throat ; hence the presence of food in the wound cannot in all cases be considered an evidence of injury to the food passage. In some cases this may possibly be due to wound of the superior laryngeal nerve, but it quite as frequently occurs in cases in which it is certain that this nerve is uninjured. It is then a bad sign, and is never met with until a semi-asphyxial condition has come on, by which nervous irritability is blunted, or until inflammation has been set up about the rima glottidis, giving rise to so much swelling as to interfere with the natural action of the muscles, and to deaden the perception of the part to the contact of a foreign body. In these cases also the sensibility of the air-passage generally is much lowered, so that mucus accumulates in the bronchi, even to a dangerous extent, the patient not feeling the necessity for expectoration, and often, indeed, having much difficulty in emptying his chest ; his efforts at clearing the bronchi being reduced to a forced expiration, a true cough being impossible while the wound is open below the glottis.

The occurrence of *bronchitis* and septic *broncho-pneumonia* is a frequent cause of death in patients who survive the immediate effects of the wound. This is due in many cases partly to the direct admission of cold air, without its being warmed by passing through the nasal cavities, but much more often

it results from the inhalation of the septic discharges from the wound. At the *post-mortem* examination of these cases the bronchi are found intensely injected; the lungs are as a rule swollen and œdematous throughout, and here and there patches of consolidation will be felt. On cutting into these they will be breaking down and softening in the centre, sometimes forming cavities almost like abscesses. They differ, however, from the secondary abscesses of pyæmia in being scattered through the lung and not specially on the surface; and if a patch be found in an early stage, it will be seen that there is no hæmorrhagic infarct preceding the softening, but that the air-vesicles are distended with opaque puriform secretion, and that the cavities are formed by the coalescence of the distended air-vesicles through destruction of their walls. The pathology of the process seems to be that septic matter from the wound is inhaled and lodges in the smaller bronchi where it sets up acute purulent catarrh with decomposition of the secretions. The decomposing secretions excite inflammation terminating in gangrene of the surrounding tissue of the lung. In some cases extensive areas of the lung may thus become gangrenous.

The *depressed mental condition* of the patient also is usually unfavourable to recovery in all those instances in which the wound is suicidal.

Treatment.—The same general principles are required as in the management of those wounds of the throat that do not open up the mucous canals in this region. Hæmorrhage must be arrested by ligature of all the bleeding vessels, whether arteries or veins, so that no oozing or trickling into the wound may take place. In some cases the hæmorrhage consists principally of general venous oozing which cannot be stopped by ligature, the patient drawing a large quantity of blood into the air-passage through the wound. In these circumstances I have found it useful to introduce a large silver tube into the aperture in the windpipe, and to plug the wound around it. So soon as the bleeding has fairly ceased, the plugs and the tube must be removed.

The edges must next be brought together by a few stitches introduced at the sides, and by attention to position, the head being fixed by tapes as described at p. 810. I think, with Liston, that in these cases the wound should never be closely sewn up, nor stitches introduced into the centre of the cut. If the centre of the integuments be closely drawn together, coagula may accumulate behind them, in the deeper parts of the wound, so as to occasion a risk of suffocation; and, as the wound must eventually close by granulation, no material advantage can possibly be gained by this practice. There is an exception, however, to this rule of not using stitches in the central part of the wound in cut throat. In cases in which the trachea has been completely cut across, a stitch or two on each side of the tube is necessary, in order to prevent the wide separation of the two portions that would otherwise take place, owing to the great mobility of the larynx and upper end of the windpipe.

In order to lessen the liability to inflammation of the lungs, the patient should be put into a room, the temperature of which is raised to about 70° Fahr., with a piece of lightly folded muslin, acting as a filter, laid over the wound. So soon as the cut surfaces begin to granulate, wet-dressings may be applied, and the edge of the wound brought into apposition by strips of plaster, and a compress if necessary. During the treatment, the principal danger proceeds from inflammatory affections of the chest; these must accordingly be counteracted by the temperature in which the patient is placed, and

by making every effort to prevent as far as possible the accumulation of decomposing discharges about the wound. It must, however, be remembered that the mental depression, and the bodily exhaustion from loss of blood, that are common in these cases, do not allow of any lowering treatment.

The **administration of food** in these cases always requires much attention. As a general rule, the patient should be kept on a nourishing diet, with a moderate allowance of stimulants. If, as not uncommonly happens, the food-passage be opened in consequence of the wound extending into the mouth, the pharynx, or the œsophagus, it is of course impossible for the patient to swallow, and the administration of nourishment becomes very difficult. This is best accomplished by means of a gum-elastic-catheter passed through the mouth into the gullet or stomach. This is easier than passing the instrument through the nose, and much better than introducing it through the wound. In this way a pint or more of the strongest beef-tea or soup, mixed with two or three eggs, and having an ounce or two of brandy added to it, should be injected regularly night and morning, until the patient is able to swallow. In those cases in which the wound is above the larynx, there is occasional danger of the supervention of œdema of the glottis; should this occur, tracheotomy may be necessary to prolong the patient's life.

As consequences of wounds of the throat, we occasionally find stricture of the trachea, or aërial fistula. If the vocal cords have been injured, loss of voice may follow.

Aërial Fistula may sometimes form owing to the skin doubling in and becoming adherent to the edges of the wound in the air-tube, and most frequently occurs when the cut is in the thyro-hyoid space; adhesion taking place between the inverted integuments and the os hyoides above, and the surface of the thyroid cartilage below. The same may occur in the crico-thyroid space, and indeed at any part of the larynx that has been opened. When this happens, the fistula tends to remain patent. In these circumstances, I have found the following operation successful.

The edges of the fistulous opening having been freely pared, and the knife passed under them for some distance so as to detach them from the subjacent parts, a vertical incision is made through the lower lip of the opening, so as to split it downwards. Two points of suture are then inserted into each side of the horizontal incisions, bringing their edges into contact, *but the vertical cut is left free* for discharges and mucus to drain through, and for the expired air to escape, lest emphysema occur. Unless this outlet be afforded, these fluids will burst through the sutures, and thus destroy union of the edges.

It is not in every case that an aërial fistula can be safely closed. In some instances the larynx becomes contracted either by drawing in of the wound, or by thickening of the mucous membrane above the artificial opening to such an extent that the fistula becomes essential, in addition to the orifice of the glottis, for the purposes of respiration. In such circumstances, any attempt at closing it will be attended or followed by symptoms of impending asphyxia; and it may be necessary to leave the opening free, or even, as happened in a case under my care, in which an opening was left in the crico-thyroid membrane of a girl who had attempted suicide by cutting her throat, to enlarge the opening and to introduce a silver tube in order to relieve the breathing from the effects of the laryngeal constriction.

Foreign Bodies in the Air-Passage.—A great variety of substances

have been found in the air-passage: such as nut-shells, beans, cherry-stones, teeth, meat, money, buttons, pins, fish-bones, bullets, pills, pebbles, and pieces of stick. These foreign bodies are not introduced into the air-passage by any effort of deglutition, for no substance can be *swallowed* through the glottis; but they are *inhaled;* thus, if a person, whilst holding anything in his mouth, make a sudden inspiration, the current of air may draw it between the dilated lips of the glottis into the larynx.

The symptoms vary, according to the situation in which the foreign body is lodged, its nature, and the period that has elapsed since the occurrence of the accident. The foreign body may lodge in one of the ventricles of the larynx; if light, it may remain in the trachea, and be carried up and down by the movement of the air in expiration and inspiration; if too heavy for this, it will fall into one or other of the primary divisions of the trachea, and, as Aston Key has observed, will most commonly be found in the right bronchus. The explanation of this has been pointed out by Gray, who states that on making a transverse section of the trachea, and taking a bird's-eye view of the bifurcation, the septum will be seen to be considerably to the left of the middle line; so that any foreign body falling down the trachea would naturally have a greater chance of entering the right than the left bronchus, although the left bronchus is in a more direct line with the trachea than the right. The greater size of the right bronchus would also favour the entrance of a foreign body into it. If the substance be small, it may pass into one of the secondary divisions of the bronchi; and, if it continue lodged here for a sufficient length of time, may make a kind of cavity for itself in the substance of the lung, where it may either excite suppuration round it or become encysted.

The *Symptoms* may be divided into three stages: 1. Obstruction, immediately following the introduction of the substance; 2. Irritation, produced by its presence; and 3. Inflammation, coming on at a later period.

1. **Symptoms of Obstruction.**—The immediate symptoms vary somewhat according to the size and nature of the body, and the part of the air-tube that it reaches. In all cases there is a feeling of intense suffocation, with great difficulty of breathing, and violent fits of spasmodic coughing, often attended by vomiting; during which the foreign body may be expelled. Indeed, its partial entry and immediate extrusion by coughing are not uncommon. In some cases, immediate death may ensue at this period. If the body have entered the air-passage fully, there is violent coughing, with feeling of suffocation for an hour or two, accompanied by lividity of the face, great anxiety, and sense of impending death. There is also usually pain about the episternal notch. The symptoms then gradually subside, but any movement on the part of the patient brings them on again with renewed violence. All these symptoms are most severe if the foreign body remain in the larynx; the voice being then croupy, irregular in tone, or altogether lost. If it be lodged elsewhere, so often as it is coughed up, and strikes against the interior of the larynx, an intense feeling of suffocation is produced; and if it happen to become impacted there, sudden death may result, even though it be not of sufficient size to block up the air-passage, apparently by the spasm that is induced. Many years ago I saw a boy die before tracheotomy could be performed, in consequence of a flat piece of walnut-shell that had entered the trachea being suddenly coughed up, and becoming impacted in one of the ventricles of the larynx. The symptoms,

during this period, are much less severe when the foreign body is in the trachea or bronchi.

When there is a suspicion that the foreign body is lodged in the larynx, a laryngoscopic examination should be made, when it may, perhaps, if large—as a plate with false teeth—be seen between the vocal cords. Small bodies also have several times been detected in this way lodging in one of the ventricles of the larynx.

2. **Symptoms of Irritation.**—When the foreign body has passed into the air-passage, and the immediate effects produced by its introduction have passed over, another set of symptoms, dependent on the irritation produced by it, is met with ; and it is during the occurrence of these that the patient is most generally brought under the Surgeon's observations.

The **General Symptoms** consist of occasional fits of spasmodic cough accompanied by much difficulty of breathing, a feeling of suffocation, and an appearance of urgent distress in the countenance. These attacks do not occur when the patient is tranquil, but come on whenever the foreign body is coughed up so as to strike the larynx, and the upper and more sensitive parts of the air-passage. As a general rule, the distress is less, the lower the substance is lodged ; the sensibility of the lower portion of the trachea and that of the bronchi being much less acute than that of the larynx and of the upper part of the trachea. In consequence of the irritation, there is usually abundant expectoration of frothy mucus. These symptoms often remit for a time, more particularly if the foreign body become fixed. In some cases, indeed, there appears to be so little distress some days after the accident, that considerable doubt may exist whether any foreign body really be lodged in the air-passage or in the lungs ; and much valuable time is often lost by the indisposition of the Surgeon to adopt active measures.

The **Physical Signs** depend necessarily upon the situation of the foreign body. If this be loose and floating, it may be heard, on applying the ear to the chest, moving up and down, and occasionally striking against the side of the trachea. If it be fixed, it will necessarily give rise to a certain degree of obstruction to the admission of the air beyond it, perhaps occasioning sibilant or sonorous rhondii during either inspiration or expiration or both. If it be impacted in the larynx, the voice will be hoarse and croupy, and there will be a loud rough sound in respiration, with much spasmodic cough and distress in breathing. If it be impacted in one bronchus, the physical signs will vary according to circumstances. If the foreign body be angular or perforated peculiar sibilant and whistling noise may be heard as the air passes over or through it. If the foreign body completely obstructs the bronchus, the respiratory murmur will be wanting on the side on which it is lodged. As a rule the obstruction is somewhat valvular in character, allowing a little air to be forced out during expiration but none to enter in inspiration, and extreme collapse of the affected lung may thus arise. There will then be absolute dulness on percussion ; deficiency on measurement and a want of expansion during inspiration. In other cases in which the form of the body is such as not to obstruct the bronchus, the physical signs will be much less marked. If one of the subdivisions of either bronchus be occupied by the foreign body, the entrance of air will be prevented in the corresponding lobe of that lung, though it enter freely every other part of the chest.

3. **Inflammation.**—After a foreign body has been lodged for a day or two,

inflammation of the bronchi or lungs is apt to be set up; in some cases, however, this occurs only after a considerable time has elapsed, or, perhaps, not at all—much depending, of course, on the shape and character of the irritant. If the foreign body completely obstruct one bronchus, the corresponding lung becomes gradually collapsed; and after a time abscesses form in it, apparently in consequence of the retention of the natural secretion in the smaller bronchi and air vesicles. If it continue to lodge, it generally forms for itself a cavity in the substance of the lung, whence purulent and bloody matters are continually expectorated, until the patient dies of phthisis in the course of a few months, or a year or two. Occasionally, however, the substance has been coughed up after a very long lodgment, the patient recovering.

Prognosis.—This depends more upon the nature of the foreign body and its size than on any other circumstances. If it be rough, angular, and hard, there is necessarily much more risk than if it be soluble in, or capable of disintegration by, the mucus of the air-passage. So long as the foreign body is allowed to remain, the patient is in imminent danger, either from immediate and sudden suffocation, or from inflammation at a more remote period.

The danger depends greatly upon the length of time during which the body is allowed to lodge. Of 62 cases which I collected in 1850 (4 of which had fallen under my own observation), I found the time that the foreign body was allowed to remain in, and the result of the case, stated in 49 instances.

PERIOD OF RETENTION.	NUMBER OF CASES.	RE-COVERED.	DIED.
Less than 24 hours	8	6	2
Between 24 and 48 hours	4	3	1
Between 48 hours and 1 week	13	6	7
Between 1 week and 1 month	8	4	4
Between 1 month and 3 months	3	3	0
Between 3 months and 1 year	6	4	2
More than 1 year	7	4	3
Total	49	30	19

From this it would appear that, if the patient escaped the danger of the immediate introduction, the greatest risk occurred between the second day and the end of the first month, no fewer than 11 patients out of 21 dying during this period; and then that the mortality diminished until the third month, from which time it increased again.

The cause of death varies also according to the period at which the fatal result takes place. During the first twenty-four, and, indeed, forty-eight hours, it happens from sudden asphyxia and convulsions. During the first few weeks it is apt to occur from inflammatory mischief within the chest: and after some months the patient will be carried off by the gradual exhaustion consequent upon the formation of abscesses in the lung.

Spontaneous expulsion of the foreign body, usually in a violent fit of coughing, occasionally occurs. Gross of Philadelphia finds that there are 49 cases on record, in which the body was spontaneously expelled, the patient recovering. Of these, in 37 it was expelled during a fit of coughing. The period during which a foreign substance may remain in the air-passage before it is spon-

taneously expelled, varies from a few minutes to many months or years; in one case, a piece of bone introduced at the age of three, was not ejected until sixty years had elapsed. Tulpius relates a case in which a nut-shell was coughed up after being lodged for seven years; and Heckster one in which a ducat was thus brought up after a lapse of two years and a half; the patients, in both instances, recovering. In other cases death may ensue, although the foreign body is coughed up; thus Sue relates an instance in which a pigeon-bone was spat up seventeen years after its introduction, the patient, however, dying in little more than a year from marasmus. In eight of the cases collected by Gross, death followed the spontaneous expulsion.

Treatment.—This accident is always very serious, and hence requires prompt and energetic means to be used in order to save the patient; and fortunately the means at our disposal, consisting of the simple operation of opening the trachea, and thus facilitating the expulsion of a foreign body, are usually highly successful. Of 60 cases in which the result was noted, I found that 37 lived, and 23 died; but on analysing these cases more closely, it appeared that in 39 no operation was performed; the expulsion of the foreign body being effected by the efforts of nature. Of these 23 died, and 16 lived. In the remaining 21 cases, tabulated below, tracheotomy was performed; of these 18 lived, and only three died, showing a remarkable success attendant on this operation.

PERIOD OF RETENTION.	NUMBER OF CASES.	CURED.	DIED.
Less than 24 hours	3	2	1
Between 24 and 48 hours	2	2	0
Between 48 hours and 1 week	9	8	1
Between 1 week and 1 month	5	4	1
Between 1 month and 3 months	2	2	0
Total	21	18	3

The statistics as to the result of operations for the removal of foreign bodies from the air-passages have been worked out chiefly by Dr. Gross, Mr. Durham, and Dr. West (U.S.A.).

Dr. Gross has collected the particulars of 85 cases not operated on. Of these 56 recovered and 29 died, the deaths amounting to 34·11 per cent. Tracheotomy was done in 98 cases; of these 83 recovered and 15, or 15·30 per cent., died.

Durham collected 271 cases not operated on. Of these 156 recovered and 115, or 42·2 per cent., died; whilst of 283 cases operated on, 213 recovered and 70, or 24·2 per cent., died.

Dr. West (U.S.A) has collected 1000 cases. Of these, in 63 cases the foreign body was removed by forceps, with or without the aid of the laryngoscope. Of the remaining 937 cases, 599 were not operated on. Of these 460 recovered and 139, or 23·20 per cent., died. In 398 cases the air-passages were opened. Of these 245 recovered and 93, or 27·42 per cent., died.

Taking the combined results of these three tables and comparing them in reference to the particular operation performed, we find that the results are as follows: of laryngotomy there were 70 cases, in all of which probably the

foreign body was impacted in the glottis, with 56 recoveries and 14, or 20 per cent., of deaths; laryngo-tracheotomy, 59 cases, with 44 recoveries and 15, or 25·42 per cent., deaths; tracheotomy was performed in 605 cases, with 449 recoveries and 156, or 25·78 per cent., deaths. The broad result that comes out from these calculations is, that after laryngotomy for the removal of foreign bodies from the air-passages one patient in five dies, whereas after laryngo-tracheotomy and tracheotomy the mortality is one in four.

Emetics, sternutatories, and succussion of the body, are all either useless or dangerous. Inversion of the body has succeeded in several instances, and might be tried before operation is had recourse to, more particularly if the foreign body is heavy, as a coin, and be movable in the air-passage. Padley caused the ejection of a sixpenny-piece in this way from the trachea of a man, and he recommends the supine as a safer and better position than the prone. There is undoubtedly danger, in inversion, of the supervention of laryngeal spasm, but statistics do not prove that any fatal consequences have resulted from this cause. Should, however, the attempt at expulsion by inversion of the body bring on an attack of laryngeal spasm, it should be abandoned, as not only useless but in the highest degree dangerous.

When *the foreign body is lodged in the larynx*, it can be detected by laryngoscopic examination, and may be removed by forceps, or such other means as the ingenuity of the Surgeon may suggest. This may sometimes be done a considerable length of time after its impaction. Thus, in a case recorded by Petrie of Liverpool, a penny was successfully removed by forceps after having been impacted six years in the larynx of a boy.

Should it, however, not be possible to extract the foreign body through the mouth, tracheotomy must be performed, and an attempt made to dislodge it from below by means of a feather passed up into the mouth, or it may possibly be seized and brought out by the wound. Should this fail, the operation of **Thyro-chondrotomy**, more often, but incorrectly, called **Thyrotomy**, should be performed. The operation is the same as that for intra-laryngeal tumours, and will be described in the Chapter on Diseases of the Throat. It is of importance that it should not be delayed, for the foreign body, more especially if rough or irregular, as a piece of bone, will shortly excite inflammation and ulceration of the mucous membrane and possibly entail permanent impairment of voice or of respiration.

When *the foreign body has passed beyond the larynx*, or is not to be recognized by means of the laryngoscope, inversion may perhaps be tried in some cases, but, as a rule, tracheotomy ought to be performed at once. And this should be done, even though the symptoms be not urgent. There is often a remission in the symptoms, a period of deceptive security, by which the Surgeon must not be put off his guard. But, it may be asked, for what purpose is the trachea opened? Why should not the foreign body be expelled through the same aperture by which it has entered? The opening in the trachea performs a double purpose; it not only serves as a ready and passive outlet for the expulsion of the foreign body, but also as a second breathing aperture in the event of its escaping through the glottis. The advantage of the opening in the trachea as a ready aperture of expulsion is evident from the statistics given by Durham of 212 cases in which tracheotomy was performed for a foreign body in the air-passages. One hundred and fifty-seven recovered: in 64 of these spontaneous expulsion took place through the tracheal opening:

in 35 spontaneous expulsion occurred from the mouth, and in 58 it was removed by forceps or other instruments. Fifty-five died ; in 48 of these the body was retained till death, in 2 it was expelled from the mouth, and in 2 from the wound immediately after the operation, and in 3 it was removed by forceps.

The reason why the foreign body usually passes out of the artificial opening in preference to escaping by the glottis, is, that the sides of the former aperture are passive, whereas those of the latter are highly sensitive and contractile. Before the operation is performed, it will be found that the great obstacle to expulsion is not only the sensitiveness of the larynx, great irritation being induced when it is touched from within, but also the contraction of the glottis, by the closure of which not only is the expulsion of the foreign body prevented, but respiration is impeded. Every time the foreign body is coughed up so as to touch the interior of the larynx, intense dyspnœa is produced, owing to sudden and involuntary closure of the glottis, by which respiration is entirely prevented and suffocation threatened ; the expulsion of the body is consequently arrested, unless it by chance take the glottis by surprise, and pass through it at once in the same way that it has entered it, without touching its sides. If it be arrested by the spasm in the glottis it is inevitably drawn down into the trachea again by the deep inspiration that follows the relaxation of the spasm. If there be a second breathing aperture, though the larynx is equally irritated by the foreign body, yet this dyspnœa cannot occur, respiration being carried on uninterruptedly by one opening whilst the foreign body escapes through the other ; and thus, in these circumstances, it may pass through the glottis with but little inconvenience. In performing the operation of tracheotomy for a foreign body in the air-passages, the opening must be made freely ; no tube must be introduced, but the edges of the wound must be kept open by blunt hooks, made of bent wire, and secured behind the neck by a piece of tape.

In some cases, the foreign body is expelled at once after the trachea has been opened ; in others, not until some hours, days, or even weeks, have elapsed. Thus, in Houston's case, a piece of stick was not coughed up until ninety-seven days after the operation ; and in Brodie's case, in which the celebrated engineer, Brunel, was the patient, sixteen days elapsed before the half-sovereign came away.

The expulsion has in some instances been facilitated by inverting the patient, shaking him, or striking him on the back. In cases in which the foreign body has not been readily expelled, forceps and other instruments have been introduced through the wound in the trachea to extract it. But, although in many instances this has succeeded, as in a case in which Walters of Reigate removed a trachea-tube that had accidentally slipped five inches into the air-passages, these proceedings should not be lightly undertaken. It is better always to wait a time, as in a large number of successful cases expulsion has not taken place spontaneously till more than twenty-four hours after the operation. If the body does not come up spontaneously by the end of the second day, exploration of the trachea is perfectly justifiable. The patient must be put fully under an anæsthetic, and even then the introduction of the instrument will cause a violent spasmodic cough. If the nature of the foreign body be known the instrument must be adapted to it. If it be of metal, glass, or china, its position can first be detected by means

of a probe. If it be of the form most easily to be seized by forceps, Gross's tracheal forceps, or Durham's flexible forceps may be used. It is difficult, however, in using forceps to avoid passing the blades down two separate bronchial tubes and thus seizing the septum between them. A loop of stiff wire, bent at its extremity to an angle so that it can be directed into either bronchus, will be found very useful in dislodging a round body impacted in a bronchus. In this way a plum-stone was easily dislodged and removed in a case which occurred in University College Hospital some years ago, and the child rapidly recovered. Should the attempt fail, the wound should be kept open by means of blunt hooks for a week or ten days longer, when perhaps it may be ejected. After the escape of the foreign body, the opening in the trachea must be closed.

Scalds of the Mouth, the Pharynx, and the Glottis, occasionally occur from attempts to swallow boiling water; or these parts are scorched by the inhalation of hot air or flame. The scalding happens chiefly to the children of the poor, who, being in the habit of drinking cold water from the spout of a kettle, inadvertently attempt to take a draught from the same source when the water is boiling. The hot liquid is not swallowed, but, though immediately ejected, it scalds the inside of the mouth and pharynx, giving rise to much inflammation, which, extending to the glottis, will produce œdema of it, and thus speedily destroy life by suffocation. In three cases which I examined after death, there was no sign of inflammation below the glottis, though the lips of this aperture were greatly swollen; and this I believe to be invariably the case, the inflammation not extending into the interior of the larynx, as was pointed out by Marshall Hall. The accident always reveals itself by very evident signs; the interior of the mouth looks white and scalded, the child complains of great pain, and difficulty of breathing soon sets in: which, unless efficiently relieved, may terminate in speedy suffocation. In those cases in which these parts have been similarly injured by the flame produced by the explosion of gas or of fire-damp being sucked into the mouth, the same conditions present themselves.

In the **Treatment** of this injury, the main point to attend to is to subdue the inflammation before it involves the glottis to a dangerous extent. With this view, leeches should be freely applied to the neck, and calomel with antimony administered. If symptoms of urgent dyspnœa have set in, tracheotomy must be performed without delay; and a tube must be introduced into the aperture so made, and kept there until the swelling about the glottis has subsided. In the majority of the cases, however, that have fallen under my observation, in which this operation has been performed, the issue has been a fatal one, from the speedy supervention of broncho-pneumonia; but as it affords the only chance of life when the dyspnœa is urgent, it must be done, though its performance in very young children is often attended by much difficulty, from the shortness of the neck and the small size of the trachea.

ASPHYXIA OR APNŒA.

Asphyxia, or, as it is more correctly termed, Apnœa, may arise from various causes. The following classification is derived from a table by Harley.

1. **Mechanical Impediment to the Entrance of Air into the Lungs.**

A. **From Accident:** either (1) *external*, as in pressure on the trunk pre-

venting expansion of the chest; pressure on the throat; smothering; injury of the spinal cord causing paralysis of the respiratory muscles; penetrating wound of the chest, admitting air; or (2) *internal*, as in obstruction of the fauces or larynx by foreign bodies, or in constriction of these parts from the application of irritating fluids. B. From **Disease**; as in pressure on the trachea by an aneurism or other tumour; œdema of the glottis; obstruction of the air-passage by tumour; accumulated mucus, &c.

2. **Drowning.**

3. **Absence of Oxygen,**—nitrogen, hydrogen, or some other harmless gas being inhaled.

4. **Accumulation of Carbonic Acid Gas in the Blood.**

5. **Inhalation of Toxic Gas or Vapour.**

Several of the conditions above enumerated as producing apnœa have been already described in the preceding pages; and others will be considered when we speak of diseases of and operations on the Air-passage. In this place we will speak of the Surgical management of cases in which respiration has been suspended by Drowning, Hanging, and the respiration of Noxious Gases.

The General subject of Suspended Animation from these various causes cannot be discussed here, but we must briefly consider some points of practical importance in its treatment.

In cases of **Drowning**, life is often recoverable, although the sufferer may have been in the water for a considerable time; for, though *immersed*, he may very probably not have been *submersed* during the whole time. The period after which life ceases to be recoverable in cases of submersion cannot be very accurately estimated. The officers of the Royal Humane Society, who have great experience, state that most generally persons are not recoverable who have been more than four or five minutes under water. In these cases, however, although submersion may not continue for a longer period than this, the process of asphyxia does; for it does not cease on the withdrawal of the body from the water, but continues until the blood in the pulmonary vessels is aërated, either by the spontaneous or artificial inflation of the lungs. As several minutes are most commonly consumed in withdrawing the body from the water and conveying it to land, during which time no means can be taken to introduce air into the lungs, we must regard the asphyxia as continuing during the whole of the period that intervenes between the last inspiration before complete submersion, and the first inspiration, whether artificial or spontaneous, after the removal of the body from the water. The latest time at which life can be recalled, during this period, is the measure of the duration of life in asphyxia. If, during this period, the action of the heart should cease entirely, I believe, with Brodie, that the circulation can never be restored. But although we may put out of consideration those marvellous cases of restoration of life that are recorded by the older writers, and which are evidently unworthy of credence, are we to reject, as exaggerated and apocryphal, cases such as that by Smethurst, in which recovery took place after ten minutes' submersion; that by Douglas of Havre, in which the patient was not only submersed, but had actually sunk into, and was fixed in the mud at the bottom of the harbour for from twelve to fourteen minutes; or that by Weeks, in which the submersion, on the testimony of the most credible witnesses, exceeded half an hour? I think that it would be unphilosophical in the extreme to deny the facts clearly stated by these gentlemen; the more

so that in these, as in many other instances of apparent death from drowning, life appears to have been prolonged by the patient falling into a state of syncope at the moment of immersion. We must therefore not despair of recovery, but should employ means of resuscitation, even though the body have been actually under water a considerable time.

There are certain minor means often employed in the case of persons who have been immersed in water, and are apparently drowned, which appear to be well adapted for the treatment of the less severe forms of asphyxia, or rather cases of syncope from fright and immersion in cold water. These consist, after the nose and mouth have been cleared of any collections of mucus, in the application of heat by means of a bath at about the temperature of 100° Fahr. until the natural warmth is restored; in the employment of brisk friction; and in passing of ammonia to and fro under the nostrils. It is evident that these measures can have no direct influence upon the heart and lungs, but can only act as general stimuli to the system, equalizing the circulation if it be still going on; and, by determining the flow of blood to the surface, tending to remove those congestions that are not so much the consequences of the asphyxia, as of the sojourn of the body for several minutes in cold water; they would therefore be of especial service during the colder seasons of the year. A hot bath may also, by the shock it gives, excite the reflex respiratory movements. With the view of doing this with a greater degree of certainty, cold water should be sprinkled or dashed upon the face at the time when the body is immersed in the hot bath, as in this way a most powerful exciting influence can be communicated to the respiratory muscles, and the first object of treatment in all cases of asphyxia—the re-establishment of respiration—would more rapidly and effectually be accomplished; deep gaspings ensuing, by which the air would be sucked into the remote ramifications of the air-cells, aërating the blood that had accumulated in the pulmonary vessels, and enabling it to find its way to the left cavities of the heart, and thus to excite that organ to increased activity. These means, then, are useful in those cases of asphyxia in which the sufferer has been but a short time submersed, and in which the heart is still acting, and the respiratory movements have either begun of their own accord on the patient being removed from the water, or in which they are capable of being excited by the shock of a hot bath, aided by the dashing of cold water in the face. At the same time the lungs may be filled with pure air, by compressing the chest and abdomen, so as to expel the vitiated air, and then allowing them to recover their usual dimensions by the natural resiliency of their parietes. A small quantity of air will, in this way, be sucked in each time the chest is allowed to expand, and thus the re-establishment of the natural process of respiration may be much hastened. This simple mode of restoring the vital actions should never be omitted, as it is not attended with the least danger, and does not in any way interfere with the other measures employed. Marshall Hall has recommended that the patient be turned prone, so that the tongue may hang forwards, and the larynx thus be opened; and that respiration be then set up by gentle pressure along the back, and by turning the patient on his side at regular intervals. If, by these means, we succeed in restoring the proper action of the respiratory movements, it will be necessary merely to pay attention to the after-treatment. Should we, however, fail in restoring respiration, we should have recourse to other and more active measures.

In the more severe cases of asphyxia, warmth should be applied by means of a hot-air bath, by which the natural temperature of the body may be re-established. The most direct and efficient means, however, that we possess for the re-establishment of the circulation in these cases is certainly **Artificial Respiration.** In this way alone can the pulmonary artery and the capillaries of the lungs be unloaded of the blood that has stagnated in them, and the left side and substance of the heart will be directly and rapidly supplied with red blood. The whole value of artificial respiration depends, however, upon the way in which it is employed. Inflation is not very effectual from the mouth of an assistant into the nostrils or mouth of the sufferer, as air once respired is not well fitted for the resuscitation of the few sparks of life that may be left, but it is in many instances the readiest and indeed the only mode by which respiration can be set up, especially if water or other fluids have found their way into the mouth.

The bellows, if properly constructed for artificial inflation, so that the

Fig. 341.—Silvester's Method—Inspiration.

quantity of air injected may be measured, are no doubt very useful ; and if furnished with Leroy's trachea-pipes, or, what is better, with nostril tubes, may be safely employed. About fifteen cubic inches of air may be introduced at each stroke of the bellows, and these should be worked ten or a dozen times in a minute. The lungs should be emptied by compression of the chest before beginning to inflate, and, after each inflation, by compressing the chest and abdomen ; but care must also be taken not to employ much force, lest the air-cells be ruptured. Richardson has devised a pocket-bellows for artificial respiration, consisting of two elastic hand-bellows with a single tube for introduction into the nostril. A safe, and at the same time a very efficient mode of introducing pure air into the lungs, is, by the elastic expansion of the walls of the chest. This may be effected by alternately compressing the chest and abdomen with the hand, and then removing the pressure so as to allow the thorax to expand by the natural resiliency of its parietes, and thus, each time it expands, to allow a certain quantity of air to be sucked into the

bronchi. A much more efficient method, however, is that recommended by Silvester, and adopted by the Royal Humane Society. It is carried out in the following way. The patient is laid on a flat surface on his back, with the head and shoulders slightly raised on a pillow. The tongue should be drawn and held forwards. The arms are then to be grasped just above the elbows, and to be drawn gently and steadily upwards above the head and pulled upon slightly, so as to drag on the great pectoral muscles (Fig. 341). In this position they are kept for two seconds; they are then to be brought downwards, and to be pressed for two seconds firmly against the sides of the chest (Fig. 342); at the same time an assistant may compress the lower ribs and push up the liver and diaphragm. These movements are to be repeated deliberately about fifteen times in the minute, until natural efforts at respiration are induced, when they are to be discontinued, and the ordinary means to promote circulation and warmth employed. The quantity of air introduced need not be large;

Fig. 342.—Silvester's Method—Expiration.

for, by the law of the diffusion of gases, if oxygen be introduced only into the larger divisions of the bronchi, it will rapidly find its way into the ultimate ramifications of these tubes. This last means of inflation has the additional advantage of resembling closely the natural process of respiration, which is one of expansion from without inwards, and not, as when the mouth or bellows are used, of pressure from within outwards. In one case the lungs are, as it were, drawn outwards, the air merely rushing in to fill up the vacuum that would otherwise be produced within the thorax by the expansion of its parietes; in the other they are forcibly pressed up from within, and hence there is a danger of rupture of the air-cells. Care must be taken not to use too much violence in compressing the chest. I have known a case in which the sternum and several ribs were broken in an old man during the employment of this method. In case a battery be at hand, Faradization of the phrenic nerve forms a valuable adjunct to the method of artificial respiration. It is thus carried out. It must first be ascertained that the current is of sufficient strength to cause vigorous contraction of the muscles of the ball of the Surgeon's thumb. The person in charge of the battery should stand on the right side of the

patient and press one rheophore well down on the phrenic nerve at the outer border of the sterno-mastoid, where the nerve lies on the scalenus anticus, and, while the person in charge of the Sylvester method of artificial respiration raises the arms he should press the other rheophore on the right side of the thorax in the sixth intercostal space ; when the arms are depressed he should remove the rheophore. If it is successfully carried out a distinct rush of air will be heard to enter the mouth as the rheophore is applied to the side.

Inflation of the Lungs with Oxygen Gas is likely to be of great service in extreme cases of asphyxia. I have found by experiment that the contractions of the heart can be excited by inflating the lungs with this gas, when the introduction of atmospheric air fails in doing so ; and there are cases on record in which resuscitation was effected by inflating the lungs with oxygen, when in all probability it could not have been effected by any other means. In my Essay on "Asphyxia" will be found a case of resuscitation, in which oxygen was successfully administered by Weeks after the asphyxia had continued three-quarters of an hour.

Whatever means of resuscitation are adopted, they should be continued for at least three or four hours, even though no signs of life show themselves ; and after ordinary respiration has been re-established, the patient should be kept quiet in bed for some hours. The danger of the supervention of **Secondary Asphyxia** after recovery has apparently taken place is much increased, and indeed is usually brought about, by some effort on the part of the patient that tends to embarrass the partially restored action of the heart and lungs. The patient, being to all appearance resuscitated, is allowed to get up and walk home, when the symptoms of asphyxia speedily return. Should symptoms of secondary asphyxia, such as stupor, laborious respiration, dilatation of the pupils, and convulsions, manifest themselves, artificial respiration should be immediately set up, and be maintained until the action of the heart has been fully restored.

Asphyxia from the **Respiration of Noxious Gases**, such as carbonic acid, is best treated by exposing the surface of the body to cold air, by dashing cold water upon the face, and by setting up artificial respiration without delay, if the impression of cold upon the surface do not excite these actions. There is a peculiar variety of this kind of asphyxia, which is occasionally met with among infants, the true nature of which was pointed out to me by Wakley, who, as coroner, had abundant opportunities of witnessing it, as it is not an uncommon cause of accidental death amongst the children of the poor. It is that condition in which a child is said to have been *overlaid*; the child, sleeping with its mother or nurse, being found in the morning suffocated in the bed. On examination no marks of pressure will be found ; but the right cavities of the heart and lungs are gorged with blood, and the surface is livid, clearly indicating death by asphyxia. That this accident is not the result of the mother lying upon her child, is not only evident from the *post mortem* appearances, but was clearly proved by a melancholy case to which I was called several years ago, in which a mother, on waking in the morning, found her twin infants lying dead, one on each side of her. Here it was evident, from the position of the bodies, that she could not have overlayed both. The true cause of death is partly the inhalation of, and slow suffocation by, the vitiated air which accumulates under the bed-clothes that have been drawn, for the sake of warmth, over the child's head, and partly the diminished supply of oxygen.

In such cases, resuscitation by artificial respiration should always be attempted if any signs of life be left.

Asphyxia from the respiration of **Carbonic oxide** is more frequent than Surgeons are apt to imagine. As has been already stated in the chapter on Burns, death often takes place in cases where buildings are on fire from poisoning by the respiration of carbonic oxide. According to Leblanc, it is this gas that is the poisonous agent given off in the fumes of charcoal. The effect of the respiration of carbonic oxide gas is to deprive the red corpuscles of their power to carry oxygen, and death takes place rather from the want of oxygen than from the poisonous action of carbonic oxide itself.

The inhalation of oxygen is of service in such cases; but it must be borne in mind that death is generally very rapid.

In cases of **Hanging**, death seldom results from pure asphyxia, but is usually the consequence, to a certain degree at least, of apoplexy, and possibly of simultaneous injury of the spinal cord. In these cases, bleeding from the jugular vein may be conjoined with artificial respiration.

If there should be a difficulty in setting up artificial respiration through the mouth or nose, as is more especially likely to happen when the patient has been suffocated by breathing noxious gases, or in cases of hanging, tracheotomy or laryngotomy should at once be performed, and the lungs inflated through the opening thus made in the neck.

INJURIES OF THE PHARYNX AND ŒSOPHAGUS.

Wounds of the Œsophagus are met with chiefly in cases of cut-throat, in which, as has been already stated in treating of this injury, they occasion much difficulty by interfering with deglutition.

Foreign Bodies not uncommonly become impacted in the pharynx and œsophagus, and may produce great inconvenience by their size or shape. If large, as a lump of meat, the substance may lodge in the lower part of the pharynx and compress or occlude the orifice of the glottis, and at once suffocate the patient. If of smaller size, as a gold plate with false teeth or a coin, it may lodge at the lower end of the pharynx where it is narrowed by the projection of the larynx backwards. It must be remembered that any flat body, such as a coin, if it lodge in this situation, will almost invariably lie with its surfaces looking backwards and forwards. If the foreign body be arrested beyond this point, it will usually be near the termination of the œsophagus. When it is small or pointed, as a fish-bone, pin, or bristle, it may become entangled in the folds of mucous membrane that stretch from the root of the tongue to the epiglottis, or that lie along the sides of the pharynx. In some cases it may even perforate these, penetrating the substance of the larynx, and thus producing intense local irritation, cough, dyspnœa, and suffocation. The foreign body, by transfixing the coats of the œsophagus, may seriously injure some neighbouring parts of importance. Thus, in a curious case admitted into the University College Hospital, a juggler, in attempting to swallow a blunted sword, by pushing it down his throat, perforated the œsophagus and wounded the pericardium; death consequently resulted in the course of a few days.

The **Symptoms** occasioned by the impaction of a foreign body in the food-passages are sufficiently evident. The sensations of the patient, who usually complains of uneasiness about the top of the sternum, difficulty in swallowing

solids, and perhaps an urgent sense of suffocation, lead to the detection of the accident. Should any doubt exist, the Surgeon may, by introducing his finger, explore nearly the whole of the pharynx, and should examine the œsophagus by the cautious introduction of a well-oiled probang.

If the impaction be allowed to continue unrelieved, not only may deglutition and respiration be seriously interfered with, but ulceration of the œsophagus will take place, and abscess form either behind it or between it and the trachea: or fatal hæmorrhage may ensue by perforation or ulceration of neighbouring blood-vessels.

The **Treatment** must depend upon the nature of the foreign body and its situation. Should it be large, blocking up the pharynx so as to render respiration impracticable, it may be hooked out by the Surgeon's fingers. Should asphyxia have been induced, it may be necessary to perform tracheotomy or laryngotomy at once, and to keep up artificial respiration until respiration is fully re-established when the foreign body can be removed. If it be small or pointed, as a fish-bone or pin, for instance, though it have lodged high up, the Surgeon will usually experience great difficulty in its removal, as it becomes entangled between and is covered in by the folds of the mucous membrane, where from its small size it may escape detection. In these cases an expanding probang will be found useful. After the foreign body has been removed, the patient will experience for some time a pricking sensation, as if it were still fixed. If the impacted body have passed low down into the œsophagus, the Surgeon must deal with it according to its nature. A coin can usually be caught by the instrument known as a "coin-catcher," and removed without difficulty. If the body be smooth and soft, as a piece of meat for instance, it may be pushed down into the stomach by the gentle pressure of the probang. If, however, it be rough, hard, or sharp-pointed, as a piece of earthenware, or bone, or a metallic plate, with false teeth attached, such a procedure would certainly cause perforation of the œsophagus, and serious mischief to the parts around; in these circumstances, therefore, an attempt at extraction should be made by means of long slightly-curved forceps, constructed for the purpose.

The foreign body occasionally becomes so firmly impacted in the pharynx or œsophagus, that the employment of any degree of force for extracting it would be attended with danger of perforating the œsophagus or transfixing the large vessels of the neck; in these circumstances it may become necessary to open the tube and thus remove it. The operation of **Pharyngotomy** or **Œsophagotomy** is seldom called for; if required, it may be performed by making an incision about four inches in length along the anterior border of the left sterno-mastoid muscle, the œsophagus naturally curving somewhat towards the left side. The dissection must then be carried with great caution between the carotid sheath and the larynx and trachea in a direction backwards, the omo-hyoid muscle having been divided in order to afford room. Care must be taken in this deep dissection not to wound either of the thyroid arteries, more especially the inferior one, which will be endangered by carrying the incisions too low. When the pharynx or the œsophagus has been reached, a sound or catheter should be passed through the mouth into this cavity, and pushed forwards so that its point may cause the walls to project, and thus serve as a guide to the Surgeon. This must then be cut upon, and the aperture thus made in the gullet enlarged, by means of a probe-pointed bistoury, to a sufficient size to allow the removal of the extraneous substance.

Hard and perfectly indigestible foreign bodies, such as artificial teeth, are sometimes accidentally swallowed during sleep or an epileptic fit, and, passing through the pharynx and œsophagus, drop into the stomach. In these circumstances, there are two courses open to the Surgeon; either to endeavour to extract the foreign substance, or to leave it, and allow it to pass, if possible, *per anum*. I think that the line of practice to be followed should depend on whether the foreign body produce irritation in the stomach or not. If it irritate, giving rise to continued efforts at vomiting, it should, if possible, be extracted. In order to do this, an ivory-balled probang should first be passed in to ascertain the situation of the foreign body. After this has been heard and felt, we may adopt the plan successfully employed by Little—who removed a hooked plate containing five artificial teeth from the stomach of a woman—of introducing a "coin-catcher" so as to search for, secure, and then extract it. In doing this, there is of course a great probability that the mass will be drawn up sideways; and that it may, if broad, hitch in the pharynx, whence it must be detached as well as the Surgeon can manage by a judicious combination of force and skill. Should the foreign body be small, as a coin, or even angular and sharp-pointed, as a plate with artificial teeth, and should it not irritate the stomach, it had better be left to pass through the intestines. When it is thus left, the patient should take neither purgatives nor opiates. Both are injurious: the purgatives by increasing the irritation of the bowels and the chance of their being wounded by sharp and projecting points from the plate; the opiates by arresting its progress. The better plan is to keep the patient in bed, perfectly quiet, and to give him an abundance of pultaceous food. By adopting this plan I have succeeded in getting a gold plate, with three molar teeth and a sharp curved clasping hook at each end, to pass without the slightest difficulty or pain four days after it was swallowed by a gentleman about 25 years of age. No attempt need ever be made to extract small coins from the stomach, as they will always easily pass through the intestinal canal.

If the body be of such a nature that it is impossible to remove it through the œsophagus, and it is equally unlikely that it can pass safely through the intestines, the operation of **gastrostomy** must be performed. This is seldom required except in the case of the swallowing of a fork or knife, or some such instrument, either intentionally by a lunatic, or accidentally during drunkenness, or while performing a trick. The foreign body when of this size can usually be felt without difficulty through the abdominal wall. The operation of gastrostomy for the removal of foreign bodies has been singularly successful. Durham states that of ten recorded cases only one died, and in that one œsophagotomy had been previously performed. The operation will be described in the chapter on stricture of the œsophagus.

CHAPTER XXVIII.

INJURIES OF THE CHEST.

Wounds of the Chest-Walls are not of such frequent occurrence now as formerly in the days of duelling. The soft tissues may, however, be contused, torn, or cut. The thoracic muscles, especially the pectorals, are sometimes ruptured by force applied to the arms when abducted or raised above the head. The great pectoral muscle has been torn in a boy who attempted to drop from hand to hand three rungs of a ladder at a time. Extravasation of blood, and even inflammation and suppuration, may result from such injury. Subpectoral abscess may occur from injury of the pectoral muscles, or of the areolar tissue beneath them, or it may form without any apparent cause. The pus must be evacuated early. This may be done by making an incision through the skin and then tearing through the fibres of the muscles, after the manner recommended by Mr. Hilton for the emptying of sub-muscular or deep-seated abscesses.

Wounds of the chest derive their principal interest and importance from the accompanying injury of the lungs, heart, or larger blood-vessels. When the soft parietes alone are wounded, the injury differs in nothing from similar lesions in other parts of the body ; except that it is usually slower in healing, in consequence of the want of rest caused by the movements of respiration. This is especially the case when the muscular parietes are furrowed by bullets. If the Surgeon be in doubt whether the cavity of the chest have been penetrated or not, he may endeavour to ascertain this point by careful examination with the finger, but he should never introduce a probe ; it is better for him to wait and to be guided in his opinion by the symptoms that manifest themselves, rather than, by probing the wound, to run the risk of converting it into what he dreads—a penetrating wound of the chest.

INJURIES OF THE LUNG.

Contusion of the Lung without injury to the pleura covering it may happen from severe blows on the chest, as from falls from horseback or kicks on the side. It may be complicated with fracture of one or more ribs ; but this is not necessarily a concomitant of the injury. The symptoms are as follows. After the receipt of the blow, the patient is seized with difficulty in breathing, which is apt to become paroxysmal, so as to resemble asthma. There is expectoration, at first of mucus untinged with blood. On listening to the chest, coarse crepitation, with some dulness on percussion, will be found over the injured part of the lung. After some days, the patient coughs up a small quantity of dark, coagulated, viscid blood ; and the sputa may be tinged for some time afterwards. The dyspnœa and cough become much relieved, and recovery gradually takes place.

It is probable that in these cases the lung is ecchymosed at the time of the injury, and that the blood extravasated in its tissue gradually breaks down,

being then discharged by coughing in the viscous, semi-coagulated state above described—very different from the florid frothy sputum of recent lung-wound.

RUPTURE OF THE LUNG, that is to say, a contused wound with laceration of the visceral pleura, has occasionally been observed as the result of violent compression in some cases without fracture of the ribs. Thus, a young woman was brought into University College Hospital a few years ago, who had thrown herself from a first-floor window, and had fallen with her chest against an iron bar. She died soon after admission, and it was found that death had resulted from hæmorrhage from a laceration of the root of the right lung. The chest walls were extremely elastic, and no fracture of the rib had taken place. The symptoms are identical with those of a wound of the lung. Rupture of the lung is a dangerous accident, but not necessarily fatal.

WOUND OF THE LUNG is the most common, and one of the most serious complications of injuries of the chest. Wounds of the lung may be divided into those which communicate with the external air by a wound penetrating the walls of the thorax, and those which do not. In an organ like the lung which contains air, this distinction might seem of but little importance ; but as has already been pointed out, it is the dust of the air, and not the gases, which gives rise to decomposition of extravasated blood or inflammatory effusions. The well-known experiment of Tyndall, in which he showed that the residual air—that is to say, the last part of the air driven out from the smaller bronchial tubes and the air-vesicles by forced expiration—contains no dust, proves that all the solid particles floating in the atmosphere are deposited in the larger tubes ; and, consequently, unless the wound be of sufficient depth to open these, there is no reason to fear that decomposition will take place in the cavity of the pleura, even though a considerable quantity of air may escape from the wound of the lung. Wounds of the lung vary also greatly in severity—from the superficial puncture produced by the pointed fragments of a broken rib, to a deep stab by a sword-thrust, or the wound produced by a fragment of shell or a bullet. The general constitutional effects will necessarily vary in accordance with the nature and extent of the injury.

The pleura may be opened at any part, and it is important to remember its anatomical relations. Its upper part extends into the root of the neck from one to two inches above the anterior end of the first rib, or, according to Pansch, from half an inch to one and a half inches above the clavicle. Below the limits of the pleura are as follows ; behind they both reach to the twelfth rib, and sometimes a little below it ; in the axillary line the right pleura extends to the lower border of the ninth rib, and the left to the lower edge of tenth ; in front the right pleura reaches to the junction of the seventh rib with its cartilage, and the left a little lower. Thus, a stab in the neck one and a-half inch above the clavicles may reach it, and a shot in the back that shatters the twelfth rib will wound it in its inferior pouch, where it is reflected off the last rib on to the diaphragm. In a penetrating wound of the chest, so low down as this, the diaphragm comes into such close contact with its posterior walls that it could scarcely escape injury. The abdominal cavity would thus be opened, and some of its viscera probably injured. As the lung does not descend below the tenth rib, it could be wounded only as low as the ninth intercostal space in the back, unless the tenth rib itself were penetrated.

The **Symptoms** of a wound of the lung are usually sufficiently well marked, though they necessarily vary with the extent of the injury. There is, in the first place, the immediate shock that usually accompanies the infliction of an injury on an important internal organ, in severe cases amounting to extreme collapse. The patient is at the same time seized with considerable difficulty of breathing, and in consequence of the injury to the parietes, the respiration is as a rule chiefly abdominal; this is followed by much tickling and irritating cough, and the expectoration of frothy bloody mucus; or, if a large vessel is wounded, great quantities of pure blood may be brought up. On auscultating the chest immediately after the infliction of the injury, loud coarse râles will be heard, caused by the presence of blood in the smaller bronchial tubes.

Complications.—In order to save repetition and to make the subject more clear, it will be better first to describe the complications that may attend wounds of the lung. The principal dangers attending a wound of the lung arise from bleeding, both external and internal, the occurrence of Hæmothorax, Pneumothorax, Emphysema, Pneumonia, and Empyema.

1. The **Hæmorrhage** varies with the part of the lung wounded, and the extent of the wound. If the large vessels near the root are implicated, death occurs almost instantaneously from loss of blood and suffocation. If the surface only is injured, the bleeding may be very slight. When it is abundant the patient spits up large quantities of florid frothy blood, a considerable amount of which may be swallowed and subsequently vomited. If it do not prove fatal, this bloody expectoration generally ceases in a great measure in the course of forty-eight hours, giving way to sputa of a rusty character. If there be a free external wound, there may also be copious bleeding from it; but not unfrequently the blood finds its way into the pleural sac rather than through the external aperture and accumulates in it. If there is no external wound, such blood as is poured out from the surface of the lung must necessarily find its way into the pleura. Death may arise either from the exhausting effects of this internal and concealed hæmorrhage, or from suffocation through the pressure exercised on the lungs by the blood in the pleura. Although bloody expectoration, to some extent at least, is an almost necessary and invariable accompaniment of a wounded lung, yet I have seen a laceration in that organ three inches in length, occasioned by the projection of broken ribs, which proved fatal on the seventh day from hæmothorax and pleuritic effusion, unattended by any expectoration of blood, or other positive sign of wound of the lung. The blood in these cases would probably be infiltrated into the loose tissue of the lung around and above the wound, where it would coagulate so as to offer a barrier against its escape into the bronchi, while it was being poured out where least resistance was offered to it—viz., at the point of injury in the pleura. The symptoms of this internal hæmorrhage, **Hæmothorax**, are those that generally characterize loss of blood, such as coldness and pallor of the surface, small weak pulse, and a tendency to collapse with increasing dyspnœa. The more special signs consist in an inability to lie on the uninjured side, with, in extreme cases, some bulging of the intercostal spaces, and an ecchymosed condition of the posterior part of the wounded side of the chest. If there is an open wound there will be occasional gushes of blood from it when the patient coughs. The most important signs are furnished by physical examination of the chest. As the blood gravitates towards the back of the chest, between the posterior wall and

the diaphragm, there will be gradually increasing dulness on percussion in this situation, with absence of respiratory murmur and vocal fremitus. In the upper and anterior part of the lung air continues to enter, but as the pressure increases and the lung becomes more completely collapsed, the vesicular murmur will be lost, and the breath sound become tubular in character.

An ecchymosis of the loins described by Valentin, and noticed by Larrey and others, occasioned by the filtration of blood through the wound or rent in the pleura costalis into the areolar tissue of the chest, has been looked upon by some Surgeons as pathognomonic of hæmothorax; its importance, however, is secondary to that of the auscultatory signs, as in many cases it has not been met with, and in others of non-penetrating wounds of the chest it has occurred.

2. **Emphysema**, or the infiltration of air into the areolar tissue of the body, and **Pneumothorax**, or the accumulation of air in the cavity of the pleura, are occasional complications of a wounded lung. These accidents occur more commonly when the external wound is small and oblique, than when it is large and direct, and often happen in those cases in which the lung is punctured by a fractured rib, without there being any external wound. Emphysema and pneumothorax may occur together, but either may also be met with separately. The mechanism of traumatic emphysema is most commonly as follows. The two layers of the pleura, costal as well as visceral, being punctured and torn, and the lung wounded, a quantity of air is sucked into the pleural sac at every inspiration, either through the external wound, or, if none exist, from the hole in the lung, thus giving rise to pneumothorax. At every expiration, the air that thus accumulates in the pleural sac, being compressed by the descent of the walls of the chest, is pumped into the areolar tissue around the edges of the wound; and if this be oblique and valvular, or if no external wound exist, the air being unable to escape wholly through it, finds its way at each succeeding respiration further into the large areolar planes, first about the trunk and neck, and eventually, perhaps, into those of the body generally. Under no circumstances can any air find its way back into the bronchial tubes, for although a wound in the lung allows air to pass readily in the direction of the pleura, it offers a valve-like resistance to any passage of air in the opposite direction. Though this is the way in which the most marked cases of emphysema occur, it may be occasioned otherwise. Thus, for instance, I had once under my care a woman who had extensive emphysema of the areolar tissue of the trunk from fractured ribs, but without any pneumothorax, the lung having been wounded at a spot where it was attached to the walls of the chest by old adhesions, and the air having passed through them into the areolar tissue of the body, without first entering the cavity of the pleura. I have seen extensive emphysema occasioned also by the apex of the lung being wounded by the fragments of a comminuted clavicle. Hilton has described a form of traumatic emphysema that arises from the rupture of an air-cell without any external wound. The air passes along the root of the lung into the middle, and thence into the superior mediastinum; running up along the great vessels and œsophagus, it enters the neck between the layers of cervical fascia which enter the thorax in front of the great vessels and behind the œsophagus respectively. From these the carotid and subclavian vessels, with their nerves, derive sheaths, so the air now runs along these structures into the limbs and neck.

The air which escapes from a wound of the lung is, as before stated, thoroughly filtered, and has no tendency to give rise to putrefaction of the extravasated blood or inflammatory effusions in the parts about the wound, and in the vast majority of cases of simple fracture of the ribs, complicated by a slight wound of the lung and subcutaneous emphysema, no suppuration follows the accident. I have, however, seen extensive suppuration in the areolar tissue, so that the broken parts of the fractured ribs lay bathed in pus, when the emphysema was the result of puncture of the lung by the broken rib, without any wound in the skin.

The *Symptoms of Emphysema* are very distinct. There is a puffy diffused swelling, pale and crackling when pressed upon, at first confined to the neighbourhood of the wound, if there be one externally; if not, making its appearance opposite the fractured ribs, and gradually extending over the upper part of the trunk and neck. To these parts it is usually limited: in some cases, however, which are happily rare, the swelling becomes more general, the body being blown up to an enormous size, the features effaced, movement of the limbs interfered with, respiration arrested, and suffocation consequently induced; after death, air has been found in all the tissues, even under the serous coverings of the abdominal organs. The rapidity with which the emphysema diffuses itself will depend largely upon the nature of the opening in the chest wall, whether valvular or direct, and upon whether the patient coughs or not—coughing, if violent, causing very rapid and extensive infiltration of air over the body. I have seen in such a case the scrotum blown up to the size of a cocoa-nut five minutes after the chest had been punctured. In *traumatic pneumothorax* the auscultatory phenomena are very distinctly marked; there is a diminution or complete absence of the respiratory murmur and of vocal fremitus on the affected side, with a loud tympanitic resonance on percussion, displacement of viscera, and considerable distress in breathing. If the pressure in the pleura becomes very great, respiration may be completely arrested by pressure on the opposite lung.

3. **Pneumonia.**—Every wound of the lung is necessarily followed by a localised traumatic inflammation, limited to the parts actually injured. The inflammatory exudation fills the air vesicles, and thus causes a consolidation of the lung at the injured spot. This is a necessary stage in the process of repair, and in subcutaneous injuries has little or no tendency to spread. In cases complicated by the admission of unpurified air from without, decomposition of the extravasated blood and inflammatory effusion frequently occurs, and the presence of the irritating products of putrefaction in the track of the wound may lead to an extension of the inflammation, with suppuration, and occasionally gangrene of a portion of the lung. More commonly the lung collapses, in consequence of the pressure of blood and inflammatory effusion in the pleura, and at the *post-mortem* examination, if the patient should die, the consolidation of the lung is found to extend scarcely beyond the parts actually injured by the missile or weapon by which the wound was inflicted. The comparative rarity of spreading pneumonia in cases of gunshot-wound of the lung is specially commented on in the Reports of the Civil War in America, and was noted also by Klebs and Socin in the Franco-German War of 1870.

The simple localized traumatic inflammation consequent on an injury causes but slight constitutional disturbance, and it is only in exceptional cases that it could give rise to definite physical signs. There may be a little fine crepita-

tion, and possibly a recognizable dulness; but more commonly the physical signs are obscured by hæmorrhage into the lung substance, and into the cavity of the pleura. The rusty sputa are more the consequence of the hæmorrhage into the air-vesicles than of inflammatory hyperæmia. Should spreading septic inflammation set in, the constitutional symptoms are much more grave, very high fever being caused by absorption of the products of putrefaction, the temperature reaching 104° F. or 105° F. It may then occasionally be possible to recognize the ordinary signs of pneumonia—hurried respiration, fine crepitation, dulness on percussion, increased vocal fremitus, tubular or bronchial breathing, and increased vocal resonance,—but far more commonly all these signs are wanting in consequence of the simultaneous inflammation of the pleura, with effusion into its cavity. The pneumonia that occurs as a consequence of injury differs essentially from idiopathic crupous pneumonia. The disease has of course no fixed locality, starting as it does from the wound, and it has much less tendency to spread. Moreover, it occurs most frequently in a collapsed or partially collapsed lung, and consequently there is not the same distension of the air-vesicles with inflammatory exudation. It is a most fatal complication, but not hopeless. If free drainage be provided from the pleura, the mischief may cease to spread, granulations may spring up, and the wound in the lung may gradually close.

Foreign bodies are frequently carried into the substance of the lung in gun-shot-wounds of the chest. If these are metallic, they may become encysted; if non-metallic, as pieces of clothing, they more commonly give rise to suppuration; and should the patient recover, may ultimately find their way into the bronchi, and be coughed up.

4. **Pleurisy and Empyema.**—Whenever the pleura is wounded, whether it be by a fractured rib or by a direct open wound, and whether the lung be injured or not, localized traumatic inflammation necessarily results, and the first stage in the repair of the injury in the serous membrane is adhesion of the two opposed surfaces by means of the inflammatory exudation. Afterwards firm fibrous adhesions are formed between the parietal and visceral pleura at the injured spot, thus obliterating to a certain extent the serous sac. Subcutaneous injuries of the pleura, such as are made by the ends of a broken rib, rarely give rise to any serious trouble. The inflammation remains strictly limited to the injured spot, and shows little tendency to spread. Even when the physical signs have shown that some amount of blood has been extravasated into the cavity of the pleura, the inflammation rarely reaches the stage of suppuration unless there is an external wound. If there is an external wound, the condition is always one of considerable danger. The cavity of the pleura is partly filled with extravasated blood and inflammatory exudation, that is to say, with putrescible matter, to which the air has free admission by the external wound; at the same time, in most cases, the drainage by the wound is very imperfect. Decomposition naturally follows, and the decomposing matter sets up the most intense inflammation of the pleura, rapidly reaching the stage of suppuration. The lodgment of a foreign body in the pleural cavity or an unhealthy constitutional condition of the patient necessarily favours the formation of pus in the pleura. In wounds of the pleural cavity which follow this course, the effused fluid is at first serum, with some flakes of lymph floating in it, and it is generally mixed with blood from the wounded lung. The effusion takes place very rapidly, so as to half

fill one side of the chest in two or three days. By about the third day it becomes turbid, and before the end of a week it assumes the character of pus. The discharge from the wound is often offensive, is extremely acrid, excoriating the skin. The constitutional symptoms are most severe, the temperature rising to 104° F. or 105° F. The patient may perish during the first week from absorption of the products of putrefaction. Should he survive till suppuration is fully established, the intensity of the symptoms subsides, the cavity may gradually close, and recovery take place; or death may ensue from hectic or exhaustion from prolonged suppuration. The discharge in these cases is sometimes enormous in quantity, and composed of thin serous pus. It may be sufficient, not only to soak the bed-clothes, but actually to run through on to the floor, unless the dressings are very frequently changed.

The presence of fluid in the pleura may be recognized by the physical signs; dulness on percussion and absence of respiratory murmur at the lower and posterior parts of the chest, up to a level which has a gradual tendency to ascend, and which varies according as the patient is upright or recumbent; the vocal fremitus is abolished over the fluid, and the voice sound is muffled. At the border of the fluid there is occasionally ægophony. In cases in which there is no external wound, or in which it has been closed, the whole side of the chest may be filled with fluid. There is then complete absence of all breath- and voice-sounds and of vocal fremitus, with increase of size on measurement, bulging of the intercostal spaces, and compression of the lung against the spine; and, if the left pleura be filled, displacement of the heart towards the right side—if the right pleura, descent of the liver below its normal level. When the pleuritic effusion and extravasation reach such a degree as this, there is necessarily great dyspnœa, and death will usually speedily ensue. If there be air as well as fluid in the cavity of the pleura, it can be recognized by the combination of the signs of pneumothorax at the upper part of the chest, with those of fluid at the lower. Occasionally distinct splashing sounds may be produced by gently shaking the patient. If it is desired to ascertain the nature of the fluid in the pleural cavity, a small quantity may be drawn off by means of a hypodermic syringe.

Collapse of the Lung.—In wounds of the chest as soon as air is admitted to the cavity of the pleura the atmospheric pressure on the surface of the lung and within the air-vesicles becomes equal and it would be naturally supposed that the lung would at once collapse by virtue of its own elasticity. This, however, is not the case. The chest may be largely opened and yet no collapse may take place. This seems most probably to be due to the adhesion of the two smooth moist pleural surfaces to each other. When collapse of the lung occurs early it is often due to air entering the pleura during inspiration, either from the lung or from without, and in consequence of the valve-like action of the wounded lung, or an oblique external wound, being unable to escape during expiration; consequently, as the chest walls descend, the lung is squeezed by the compressed air. This may be repeated at each respiration till no further collapse of the lung is possible. In the later stages it may be due to compression by blood or by inflammatory effusion. The complications that may attend wounds of the lung having been described we are now in a position to consider the different varieties of that injury.

Subcutaneous Wounds of the Lung from Fractured Ribs.—Slight injuries to the lung are extremely common in fractures of the ribs by direct

violence, but as has been already pointed out, are much less likely to occur in fractures by indirect violence, as in these the pointed ends of the fragments are directed outwards. These injuries rarely extend deeply into the lung. The usual symptoms are slight hæmoptysis, ceasing by the second day, followed by rusty sputa and limited dulness round the injury, and, possibly, at the base of the pleural cavity from extravasated blood. There may be a little coarse crepitation from blood in the lung. Emphysema is of frequent occurrence, but pneumothorax is a rare complication; it seems that a little air readily finds its way across the pleural cavity, without any separation of the visceral from the parietal pleura, probably in consequence of the natural adhesion of two smooth moist surfaces. Occasionally the absence of air in the pleural cavity in these cases may be due to the presence of adhesions. The emphysema in these cases is rarely extensive. These slight wounds of the lung in a healthy subject scarcely add to the gravity of the case, and require no treatment beyond that of the fractured rib.

More severe wounds of the lung may occur from fractures of the ribs, accompanied by pneumothorax, extensive emphysema and hæmothorax. These are occasionally followed by pleurisy, with effusion or even empyema. The majority of these severe injuries, however, do well so long as the patient is healthy and there is no open wound.

Penetrating Wounds of the Thorax with Wound of the Lung.—A penetrating wound is recognized by the presence of an external opening, through which air is frequently drawn in and out during respiration, with the signs before given of wound of the lung. These cases are always serious, as from the admission of air from without there is great risk of the occurrence of septic pleurisy and pneumonia. Moreover, in a large proportion of cases the injury to the lung extends more deeply than any wound which can possibly be inflicted by a broken rib.

Wounds of the Lung by sharp penetrating instruments, as knives or swords, are specially liable to be complicated by profuse hæmorrhage, both into the pleura and into the air-tubes. When penetrating the chest-wall obliquely, so as to leave a valved opening, they may give rise to emphysema and pneumothorax; in fact, it is in this class of cases that these conditions have most commonly been met with in an extreme degree. Septic pleurisy and empyema are common complications, but from the clean, incised character of the wound and the absence of foreign bodies carried into it there is a fair hope of preventing these complications and obtaining union of the external wound by the first intention if proper treatment be adopted.

Wounds of the Lung by blunt instruments, as in bullet- or shell-wounds or in machinery-accidents, form by far the gravest class of these injuries. In consequence of the form and size of the external opening emphysema is a somewhat rare complication, and when air is present in the pleura it is seldom at any degree of pressure. Hæmothorax, to a greater or less extent, is always present, and in the majority of cases, as the external wound can scarcely heal by the first intention, septic pleurisy and empyema follow the injury. It is sometimes complicated by spreading inflammation of the lung, terminating in suppuration or gangrene. These cases are frequently complicated by the lodgment of foreign bodies, such as bullets or pieces of clothing.

The **Prognosis** in wounds of the lungs is necessarily extremely unfavourable if the injury be severe. The danger will depend greatly upon whether it

be open or subcutaneous, upon the nature of the instrument inflicting the wound and upon its extent. If the lung be wounded by the sharp end of a broken rib, recovery usually ensues. Punctured wounds of the chest, penetrating the lungs, are always very serious; but here the danger will depend partly on the depth of penetration, partly on the size of the instrument that occasions the wound. The nearer the wound penetrates to the root of the lungs, the greater is the danger from hæmorrhage by the implication of the larger vascular trunks. Gunshot-wounds of the chest are far more dangerous than stabs, owing partly to the laceration attendant on a bullet-wound, but especially to the fact that the external wound can rarely heal without suppuration and consequently, unless it be prevented by antiseptic treatment, septic pleurisy and empyema, and perhaps also pneumonia, are almost certain to occur. Their danger is increased also, in many cases, by the lodgment of the bullet or other foreign bodies.

In the American Report of the War of the Rebellion, a table is given of 1609 cases of penetrating wounds of the chest, collected from various sources, including the reports of Mouat in the New Zealand War, Chenu and Matthew on the Crimean War, Stromeyer on the Danish War, and others. Of these 1049 died, being an average mortality of 65·2 per cent. In the American Civil War 8715 cases were recorded, with 5260 deaths, or 62·6 per cent. The highest mortality recorded was in the Crimean War, in which 91·6 per cent of these cases terminated fatally amongst the French troops, and 79·2 amongst the English. Longmore remarks that the apparently great mortality in the Crimean returns was due largely to the proximity of the field-hospitals to the trenches, where the patients were wounded; if they had been wounded in the ordinary circumstances of a battle, many of them would never have reached a hospital. The great danger and principal cause of death in these injuries is unquestionably the hæmorrhage that ensues. This may prove immediately fatal if one of the larger pulmonary vessels be divided. As the bleeding is most abundant at and shortly after the receipt of the wound, Hennen states that, if the patient survive the third day, great hopes may be entertained of his recovery. After this period, the chief source of danger is the occurrence of septic inflammation in the pleura and sometimes also in the injured lung, the probability of the occurrence of which is greatly increased in gunshot-injuries by the frequent lodgment of foreign bodies within the chest. The immediate cause of death at this stage is undoubtedly the accumulation of decomposing inflammatory effusion in the pleural cavity and the absorption of the products of putrefaction. This may prove fatal from the fourth to the eighth day. Emphysema is seldom a dangerous complication, though it may become so if very extensive and allowed to increase unchecked.

If both lungs be wounded at the same time, the result is almost inevitably fatal, either by the abundant hæmorrhage suffocating or exhausting the patient, or else by induction of asphyxia in consequence of air being drawn into both the pleural sacs, and thus arresting respiration. This, however, does not necessarily result; and there are a sufficient number of cases on record of recoveries after stabs or bullet-wounds traversing both sides of the chest, to show that collapse of the lungs and consequent asphyxia does not necessarily result from this double injury, which indeed has also been determined experimentally on animals by Cruveilhier.

The **Treatment** of wounds of the chest, implicating the lungs, must have reference to the various sources of danger that have just been indicated and to the nature of the wound.

The **Local Treatment** in cases of *injury of the lung from a broken rib* without an external wound is very simple. The routine system of bandaging or strapping up the chest tightly must not be followed in all cases. There are two conditions in which it is not advisable: the first is when the fragments of the broken rib are sharp and angular, and, projecting inwards on the pleura and lung, produce pain, distress, and no slight danger of further injury to these structures if pressed down upon them; second, when the lung has become compressed by the effusion of air, serum, or blood into the pleural sac. In the latter cases, tight bandaging of the chest will produce great distress; for, the lung on the injured side being already rendered useless, or nearly so, as a respiratory organ by the compression, respiration is altogether carried on by the lung on the uninjured side. If the chest be uniformly or tightly compressed, the use of this lung also is interfered with to such an extent, that a semi-asphyxial condition may ensue. In such cases, rather than bandaging the whole chest, the better plan is to strap up only the injured side from spine to sternum, so as to restrain its movements and leave the sound side free.

In a *penetrating wound of the chest by a sharp cutting instrument*, if it be a clean puncture, an attempt should be made to close it in such a way as to obtain union by the first intention. For this purpose some form of antiseptic treatment should always be adopted. The skin around the wound must be cleaned with some efficient antiseptic solution, such as carbolic acid lotion (1 in 20), and the wound itself may be wiped out by means of a sponge soaked in the same solution and held in a pair of forceps. The edges may then be brought together by sutures and the surface covered with an antiseptic dressing. In the absence of an antiseptic dressing the wound may be closed by lint and collodion, or a piece of lint may be soaked in the blood and allowed to dry upon it. If the wound be thus closed the patient must be carefully examined daily for effusion into the pleura, and the temperature must be watched. Should there be increasing dulness, with a high temperature, the fluid must be removed by means of the aspirator, and examined. Should it be turbid or purulent a free vent must be at once provided for it, either by opening up the original wound, or by making a new one at the most convenient spot.

Should the wound be large and deep, with blood and air issuing freely through it from the injured lung, it should not be completely closed, otherwise pneumothorax, and emphysema, or hæmothorax will certainly occur. It may be cleaned with an antiseptic solution, and partly closed by sutures, a large drainage tube inserted, and an antiseptic dressing applied, or in the absence of antiseptics it may be covered with a piece of oiled lint. The patient should be laid on the wounded side, and the wall of the chest may be fixed by long broad strips of plaster applied to the injured side only, an aperture being left between the strips opposite the wound. Mouat states that excellent results have followed this practice in military practice.

In *Bullet-wounds of the Lung* the wound should be carefully examined with the finger, and all foreign bodies that are within reach should be extracted. If there be any difficulty in doing this, it may be necessary to enlarge the aperture; but the Surgeon must not go too deeply or perseveringly in search

of the foreign body, lest he excite more irritation than it would if left alone. No attempt should be made to close the aperture, so that the escape of any extraneous substance that may have been left in, or of extravasated blood, or inflammatory effusions, may not be interfered with. The wound should, if possible, be cleaned with an antiseptic solution, and dressed antiseptically. If the means of doing this are not at hand, it may be covered with oiled lint, or some dry absorbent dressing.

The *Constitutional Treatment* of wounds of the lung presents nothing peculiar. During the first few hours the chief danger is loss of blood, and as the feeble state of the circulation during the state of shock that immediately follows the injury is favourable to the arrest of hæmorrhage, the patient should not be prematurely roused by the administration of stimulants. He must be kept lying on the injured side, and have ice to suck, or a little iced milk and soda-water, or barley-water, to drink, when these are obtainable. He must be forbidden to talk, and kept at perfect rest. If no complications ensue, he must be kept on moderate diet for a few days, after which he may take such food as he is inclined for.

Treatment of the Complications of Penetrating Wounds of the Lung.—Profuse *hæmorrhage* is a common complication in all wounds of the chest. It may occasionally come from a wounded intercostal or internal mammary artery, and must then be treated by the method described on p. 455. If the hæmorrhage come from the pulmonary tissue, the first indication consists in diminishing the quantity and force of the blood circulating through the lungs, and thus, by lessening the impulse of the heart and increasing the tendency for the blood to coagulate in the smaller vessels, to endeavour to arrest the hæmorrhage from these organs. If the hæmorrhage have been very abundant, the collapse and fainting consequent upon this may tend to induce a natural cessation of the bleeding, which thus often spontaneously ceases on the supervention of syncope. Should the hæmoptysis, however, continue or return from time to time, what should be done? Here a very considerable discrepancy of opinion exists amongst Surgeons; the question at issue being whether venesection should be adopted with the view of restraining the hæmorrhage, or the patient be treated by rest, low diet, ice, digitalis, and similar remedies. Up to the close of the Crimean war, the most experienced Surgeons were unanimous in their opinion, that the patient's safety lay in free and repeated venesection. John Bell, Hennen, and Guthrie, all concurred in urging the necessity of free venesection so as to keep down the action of the heart. Whenever this rises and the cough or hæmoptysis returns, recourse should be had to the lancet. In the Crimean campaign, Macleod states, that "those cases did best in which early, active, and repeated bleedings were had recourse to." In the official Report of the Medical and Surgical History of the War in the Crimea, venesection is advocated with equal decision as a means of arresting hæmoptysis. The writer states: "When hæmoptysis to any considerable or dangerous extent is present, venesection for the rapid induction of syncope seems not only allowable, but seems to afford the only chance of safety, and may even require to be repeated." However paradoxical or even irrational it might at first sight appear to endeavour to restrain one hæmorrhage by establishing another, yet the practice seemed established as the result of experience; and its good effects could be explained by the sudden induction of syncope giving time for the sealing up of the pulmonary vessels by coagulation of blood

within them. But although this was the practice up to a comparatively recent period, the views of military Surgeons on this point seem now to have undergone a complete change; and the experience derived from the great war of the rebellion in America and from the Maori war in New Zealand, has led to the promulgation of different doctrines and the adoption of a different line of practice. In the American war, venesection appears to have been generally abandoned, while reliance was placed on rest, cold, and opium for the suppression of hæmorrhage; and this practice is said to have been generally satisfactory. In New Zealand, Mouat states that bleeding was almost entirely discarded. Longmore says that, if the patient should survive, the loss of blood by venesection seems to interrupt the process of adhesion between the pleural surfaces, and other reparative measures adopted by nature, while it induces a condition favourable to gangrene, or the formation of ill-conditioned purulent effusions in large amount.

If extravasation of blood into the pleura be going on, its further effusion must, if possible, be arrested by the same means. Should, however, the hæmorrhage continue notwithstanding the employment of the means indicated, Guthrie advises that the wound should be closed, so that the blood that flows into the pleural sac may, by accumulating in this, compress the lung, and thus arrest the further escape of blood from the wounded vessels; the patient at the same time should be made to lie on the injured side, in order to increase the pressure exercised upon the wounded organ. When the bleeding has been checked in this way, the blood must be removed as early as possible from the pleural sac; for, if it be allowed to remain, it will in most cases speedily putrefy, the putrefactive ferment having found its way in before the wound was closed. Death then may take place from absorption of the products of putrefaction, or should the patient escape this, suppurative pleurisy inevitably follows. To prevent this, the pleura must be tapped with a large aspirator-needle on the fourth or fifth day, or earlier if the temperature be very high. Should it be found that the blood is free from any putrefactive change, which may possibly be the case, the extravasation is best removed by repeated aspirations, care being taken not to remove too much at one time, lest by causing a forcible expansion of the lung the hæmorrhage may be started again. If the fluid withdrawn is undergoing decomposition, a free opening must be made from the original wound with a probe-pointed bistoury, and a large drainage-tube inserted. The after-treatment will be the same as for septic empyema.

During the American war various drugs were made use of, with the intention of aiding the arrest of hæmorrhage, amongst them being tartarized antimony, aconite, gallic and tannic acids, and acetate of lead; but their effects do not seem to have been such as to justify any reliance being placed upon them. In the Crimean war the Russian Surgeons administered digitalis; but according to the present views of the action of that drug, its use could be productive only of harm.

Pleurisy and Empyema.—If the patient survive to the third day, the danger to be apprehended is no longer from hæmorrhage, but from inflammation and suppuration in the cavity of the pleura, consequent upon the decomposition of the discharges accumulated in that cavity. This is in some cases complicated by inflammation of the lung spreading from the track of the wound. Military Surgeons formerly recommended venesection as a means both of preventing and of reducing inflammation. Since, however, the part

played by the decomposition of the discharges in the pleural cavity has become fully recognized, much more importance has been attached to draining and cleaning the pleural cavity than to any efforts by means of blood-letting or drugs to subdue the local inflammation and constitutional disturbance. Possibly, in civil practice, if a case were met with in which the inflammation was confined to the lung substance, and attended by much dyspnœa in a healthy young subject, some relief might be given by venesection ; but such a condition is so rare that it may practically be excluded from our consideration. When the dyspnœa arises from pleuritic effusion, bleeding must necessarily be useless, and in fact could only be injurious by still further weakening the powers of the patient. The inflammation must be combated by removing its cause as far as possible.

In the first place every effort should be made to prevent the occurrence of decomposition, either of extravasated blood or inflammatory exudation in the cavity of the pleura by the adoption of some efficient method of antiseptic treatment. Should these fail, and the pleura become distended with decomposing discharges, the freest possible drainage must be provided by enlarging the original wound, and if necessary, making a counter-opening at the most convenient spot. All counter-openings must be made on a probe passed from the original wound and made to project between two ribs, as the relations of the walls and contents of the cavity are often much altered in these cases, and unless a guide is obtained in this way, either the diaphragm or the lung might be accidentally wounded. Large drainage-tubes should be inserted at the wound and the counter-opening if one has been made. If any difficulty is experienced in doing this, a piece of a rib may be cut away. If the discharges are offensive, the cavity of the pleura must be washed out with some antiseptic solution. König reports that he obtained very good results in the Franco-German war by using a strong solution of chloride of zinc.

It will always be necessary in these cases to support the patient's strength by abundant liquid nourishment and stimulants when they are obtainable. Pain and cough may often be relieved by opium.

If any extraneous body, such as a bullet, a piece of wadding, or of clothing, have penetrated too deeply into the chest to be readily extracted through the external wound, it would not be safe to make incisions or exploratory researches, with a view to extracting it ; for, though its presence would increase the patient's danger, yet attempts at extraction would not only add to this, but would in all probability be fatal. In many cases, bodies so lodged become surrounded by pus, are loosened, and eventually are spat up, or appear at the external wound. In other cases, they remain permanently fixed in the chest, becoming enveloped in a cyst, and so remaining for years, without producing irritation. In this way, Hennen states, a bullet has been lodged in the chest for upwards of twenty years ; and Vidal mentions the case of a man who lived for fifteen years with the broken end of a foil in his chest, which, after death, was found sticking in the vertebræ, and stretching across to one of the ribs.

The *Treatment of Emphysema and Pneumothorax* consists of little in addition to what is called for by the wounded lung. In many cases, indeed, the air becomes absorbed in three or four days without the necessity of any local interference. If, however, the pneumothorax interfere with respiration by pressure on the opposite lung, the external wound, if any exist, must be freely opened, and scarifications may be necessary to give exit to the air in the

areolar tissue. If no wound exists the pleura must be tapped as for fluid, and, if necessary, the cannula must be left in. I doubt whether emphysema alone can ever prove fatal.

Hernia of the Lung, or Pneumocele.—This is an extremely rare affection. It consists in the protrusion of a portion of the lung at some part of the thoracic walls, so as to form a tumour under the skin. It has most frequently been met with after an external wound, under the cicatrix of which the hernial swelling has appeared; but it has been known to occur from fractured ribs without any wound, and even from violent straining during labour. I have seen a case in a man who gained his livelihood by playing the cornet. In these cases it is probable that, the intercostal muscles and costal pleura having been divided or ruptured by the efforts of the patient, and not having united afterwards, the lung has, during expiration, gradually insinuated itself into the aperture so formed, until at last the hernial tumour has appeared. This protrusion may take place at any part of the thoracic parietes; thus Velpeau observed it in the supraclavicular region of a girl; but most commonly it occurs on one or other side of the chest. The tumour may attain a large size; I have heard Velpeau state that he had seen one half as large as the head. It does not appear to shorten life.

The only case, other than the above, that has fallen under my own observation is one that I saw in 1839, in Velpeau's wards at La Charité; and as the signs of the affection were well marked, I may briefly relate it, from notes taken at the time. A man twenty-nine years of age, left-handed, received in a duel a sword-wound at the inner side of, and a little below the left nipple; he lost a considerable quantity of blood, but did not spit up any. The wound healed in about a fortnight, shortly after which he noticed the tumour, for which he was admitted three months and a half after the receipt of the injury. On examination, an indurated cicatrix about half an inch in length was found a little below, and to the inner side of, the left nipple. On expiring or coughing, a soft tumour of about the size of an egg appeared immediately underneath the cicatrix, which it raised up; it subsided under pressure, or when the patient ceased to expire or to cough; and its protrusion might be prevented by pressing the finger firmly on the part where it appeared, when a depression was felt in the intercostal muscles. If the fingers were slid obliquely over the tumour, it yielded a fine and distinct crepitation, exactly resembling that produced by compressing a healthy lung, and the spongy feel of the organ could be recognized. On applying the ear, a fine crackling and rubbing sound was distinctly perceived; the tumour was resonant on percussion. The portion of protruded lung did not appear to re-enter the chest on inspiration, but was firmly fixed in its new situation. No treatment was adopted in the case, nor does any appear admissible in similar instances.

The only affection with which a hernia of the lung can be confounded, is a circumscribed empyema which is making its way through the walls of the chest. Here, however, the dulness on percussion, and the absence of respiratory murmur and of crackling under the fingers, will readily enable the Surgeon to make the diagnosis.

It occasionally happens in extensive wounds of the chest, that a portion of the lung protrudes during efforts at expiration. If the wound be free, the protruded lung may return on pressure or during inspiration. If left un-returned, it soon becomes livid and gangrenous; in these circumstances it may be removed by

the knife or ligature ; but Guthrie advises that the protruded part should never be separated from the pleura costalis by which it is surrounded at its base, so that the cavity of the thorax may not be opened ; the wound must then be closed in the usual way.

WOUNDS OF THE HEART AND LARGE VESSELS.

WOUNDS OF THE PERICARDIUM.—The pericardium may be wounded with or without penetration of the chest, and with or without injury of the heart. Without wound of the chest-wall, it may be lacerated by a severe contusion ; with penetration of the chest-wall, it may be wounded by a stab or by gun-shot.

Laceration of the Pericardium may take place from a severe blow on the chest. I have seen the membrane split down longitudinally for two or three inches, from contusion received in a fall.

The **Pericardium may be wounded** by a stab without the heart being injured. Thus I have seen a wound of the pericardium in a young man, inflicted by his sweetheart with a sharp-pointed pair of embroidery scissors.

The pericardium may be bruised or cut by an oblique gunshot-wound without damage to the heart. This I have seen happen from a pistol-bullet penetrating the chest obliquely.

In injuries such as these, collapse to a greater or less extent is always met with. This is followed by inflammation ; the ordinary auscultatory signs of pericarditis followed by effusion, such as friction, with extended dulness on percussion, become perceptible ; and there are intense thoracic oppression, dyspnœa, and restlessness, with pallor and a small rapid pulse.

In some cases of wound of the pericardium, with a superficial injury to the heart, one of the *coronary vessels* may be divided, and blood effused into the sac. In these cases the interposition of the layer of blood causes the heart-sounds to be weak and remote, the impulse of the apex to be indistinct or imperceptible, and the cardiac dulness to be widely diffused.

The *Prognosis* of cases of injury of the pericardium is necessarily very unfavourable. The heart may become choked by the intra-pericardial extravasation of blood or the inflammatory effusion.

The *Treatment* of these cases of wound of the pericardium should be conducted as far as possible on antiseptic principles. In cases of a punctured wound, should the external wound close, and the pericardium become distended with effusion to such an extent as to embarrass the action of the heart and threaten to prove fatal, the fluid must be removed by means of the aspirator. (See Tapping the Pericardium, Vol. II.) The general treatment must be conducted on those ordinary medical principles that guide us in the management of similar cases arising from causes other than traumatic.

WOUNDS OF THE HEART.—The heart may receive a wound which does not penetrate through the walls ; or one or more of its cavities may be opened by the agent that inflicts the injury. Most commonly the wound is inflicted by stab or gun-shot, and then generally no foreign body is lodged in the cardiac cavities or substance. But in some instances bullets, as well as pieces of stick, needles, iron pins, and other substances, have been lodged and encysted in the substance of the ventricles.

In the vast majority of cases, wounds of the heart are immediately fatal,

but they are not necessarily or invariably so. Much will depend on whether they penetrate or not into the cavities, and on the extent of the injury that the heart has sustained.

Non-Penetrating Wounds may be fatal at once from direct shock to the heart; or the patient may survive a few hours or days and then die of pericarditis; or he may recover and live for years, as in a case reported by West of Birmingham, in which the man lived for four and a half years. After death, evidences of extensive and severe pericarditis were found, and there was a linear cicatrix half an inch long in the anterior part of the right ventricle.

Penetrating Wounds of the Heart are almost invariably at once fatal from loss of blood and shock to the organ and system. This is especially the case if the cavities be largely opened, or much of the heart-substance destroyed. But there are many exceptions to this general law of fatality. Jamain has collected 84 cases in which people lived for considerable periods after having received a wound of the heart. Of these, in 35 cases the right ventricle was wounded, and the sufferers lived from four and a half hours to twenty-three days. In 19 cases the injury was to the left ventricle; and of these life was prolonged to periods varying from half an hour, in two cases, to six months in one instance. Both ventricles were wounded in five cases in patients living from one hour to nine and a half months; the right auricle in seven cases, the patients living from seven hours to twenty days; the left auricle in two cases, in which the patients lived respectively one and two days. In many cases, the patient has been known to walk or to run some considerable distance after the receipt of the injury. Ollivier and Sanson have collected 29 cases of penetrating wounds of the heart, which did not prove fatal in the first forty-eight hours after the receipt of the injury. On analysing these, it would appear that the rapidity of death depends greatly on the direction of the wound and the part of the organ injured. When the wound is parallel to the axis of the heart, it is not so speedily fatal as when in a transverse direction, and wounds of the auricle are more immediately followed by death than those of the ventricle; the irregular contraction of the different planes of muscular fibre that enter into the formation of the wall of the ventricle tending to obstruct the free passage of the blood through the wound, and perhaps to close it entirely. The size of the wound, however, will necessarily influence the result more materially than its direction. Not only, however, may a person live a considerable time after having received a penetrating wound of the heart, but there are many cases on record in which life has been prolonged even though a foreign body was lodged in the cavities or substance of the organ. Thus Ferrus relates the case of a man who lived for twenty days with a skewer traversing the heart from side to side; and Roux that of a man who lived twenty-one days with a portion of a file, with which he had stabbed himself, in the wall of the left ventricle. Davis and Stewart found a piece of wood, three inches long, in the right ventricle of a boy, who lived five weeks after the accident had happened; Carnochan relates a case in which the wounded man survived eleven days with a bullet deeply lodged in the substance of the apex of the heart; and Latour records the case of a soldier who lived for six years after being wounded with a musket-ball in the side, and in the right ventricle of whose heart the bullet was found lodged, lying against the septum.

The part of the heart that has been injured may be determined by attention to the situation of the wound and the direction it takes, for the situation of

the different cavities of the heart in relation to the superficial structures is constant. Thus, a stab below the fifth rib, about one inch to the sternal side of the nipple, and two inches below it, will wound the apex of the heart; a stab through the second intercostal space close to the right side of the sternum would wound the most prominent part of the ascending aorta after passing through the lung. One through the third to fifth intercostal spaces to the right of the sternum would wound the right auricle. The pulmonary artery would be reached by a thrust through the third rib on the left side at its junction with the sternum.

Olivier, Jamain, West, and especially Fischer, have collected statistics with regard to the relative frequency of wounds of the different cavities of the heart. Fischer has collected 452 cases, in which the right ventricle is stated to have been wounded in 123, the left ventricle in 101, and both ventricles in 26. In 28 cases the right auricle, and in 13 the left, was the seat of injury. The apex of the heart was wounded in 17. The reason of the frequency of wound of the right ventricle is the obvious anatomical fact that it lies more anteriorly than the left, and hence is more likely to be injured by wounds that penetrate the chest from the front—this being the most common situation of wounds that injure the heart. According to Fischer, in 258 cases the heart was wounded from the front of the thorax, in 26 from the abdomen, in 11 from behind, and in 5 from the side.

The pericardium is necessarily wounded in most cases of wounds of the heart. But there are instances on record in which a ball has entered the chest and caused a laceration of the heart-substance without penetrating the pericardium, which escaped in consequence of its firmness and fibrous character. Again, as has already been stated, the pericardium alone may be injured: Fischer has collected 51 such cases.

The **Symptoms** of a wound of the heart, when immediately fatal, are as follows. The person struck springs up convulsively, or falls suddenly prostrate; sometimes with, sometimes without, a sudden and sharp shriek. Death results from hæmorrhage, which will be profuse, and pass out beyond the pericardium, if the wound be large and that membrane be widely opened; or into the pericardium, preventing action of the heart by compression, if the wound be small. In either case, death is hastened by collapse arising from shock to the central organ of the circulation itself, and to the system at large from the wound of so important an organ.

If the wound be small and death be not immediate, there are evidences of great shock in the intense depression of vital power, the pallid and anxious countenance, and the relaxation of the limbs. The action of the heart itself is tumultuous, weak, and irregular; the pulse is scarcely perceptible; the breathing is frightfully embarrassed. If the patient survive a few days, these symptoms partially and intermittingly subside, and the ordinary signs of pericarditis come on—friction, gradually disappearing more or less completely as the pericardium becomes distended with fluid, when there will be increased dulness on percussion, with a weak impulse and elevation of the heart's apex. By auscultation the heart's sounds will be found to be feeble and muffled, especially at the apex. To these may possibly be added evidences of endocardial inflammation. Of these consecutive inflammatory complications and of their consequences the patient will most probably die, though perhaps at a remote period and after prolonged suffering.

Ruptures of the Heart from External Violence, without penetrating wounds of the chest, are not of frequent occurrence. Gamgee has, however, collected 27 published cases of this accident. On analysing these he finds that, in at least one half of the cases, the pericardium was intact; 12 of the ruptures were on the right, 10 on the left side. The right ventricle was ruptured in 8, and the left in 3 cases; whereas the left auricle was torn in 7, and the right only in 4 instances. Death is usually almost instantaneous, though there are instances on record in which the patient made some exertion after the rupture had taken place, and has even lived for several hours. In a case of rupture of the right auricle recorded by Rust, the patient survived fourteen hours. In most of the recorded cases, the injury occasioning the rupture was directly applied to the region of the heart. But instances are not wanting in which this organ has been found ruptured through one or both ventricles or in one of the auricles, without any evidence of direct injury in the cardiac region—the patient having fallen upon his head or shoulders, or having been merely thrown forcibly to the ground with serious injury to the lower extremities. In some of these cases, there is reason to believe that the rupture was produced by the spasmodic violence of the contractions of the heart, under the influence of great mental emotion or fear. The only case that has occurred in my practice was that of a man brought into the Hospital dead, having fallen from the top of a cart on to his right shoulder. On examination, the liver was found extensively torn, in fact smashed, and the pericardium was distended with blood—there being a triangular ragged aperture at the anterior part of the left auricular appendage, through which it had escaped.

Wounds of the Aorta and Vena Cava are usually as immediately fatal as those of the heart itself. In this respect, they resemble wounds of the auricles rather than those of the ventricles. Heil has, however, recorded a case in which the patient lived for a twelvemonth, after receiving a stab that penetrated the ascending aorta.

Wound of the Thoracic Duct may occur in surgical or homicidal injuries. It has happened in the ligature of the left subclavian artery, and in wounds deeply penetrating the chest. The main diagnostic symptom is a constant dripping or draining away of lymph. This condition is incurable, and would necessarily prove fatal, even if the patient escaped the primarily fatal consequences of the concomitant injury. Bradley has collected and published the following six cases which illustrate well the characters of the injury.

"Hoffmann's first case was that of a woman wounded through the left side with a knife. Following the wound there was a copious discharge of a spontaneously coagulating fluid, which was observed to be milky during digestion, and clear while the patient was fasting. In his second case, the escape of chyle followed the opening of an abscess of the posterior mediastinum. Monro relates a case where the thoracic duct was wounded by a stab; the lymph escaped externally and also into the pleural cavity, interfering with the heart's action. Guiffort's case is of a similar nature. Bonnet gives the history of a Baron Heinden, who was wounded in battle by a bullet, which escaped beneath the left scapula. From this wound there gradually began to flow an excessive quantity of lymph." In Quincke's case, "the pleural cavity became so full of extravasated lymph that paracentesis had to be performed to prevent suffocation, from which, indeed, the patient eventually died."

CHAPTER XXIX.

INJURIES OF THE ABDOMEN AND PELVIS.

INJURIES OF THE ABDOMEN AND ABDOMINAL VISCERA.

Injuries of the abdomen may be divided into Contusion of the Abdomen, with or without Rupture of Internal Organs; Non-penetrating Wounds; and Penetrating Wounds, either uncomplicated, or conjoined with Injury or Protrusion of some of the Organs contained in this cavity.

Contusions of the Abdominal Walls from blows or kicks usually terminate without serious inconvenience, but in some cases are followed by very acute peritonitis, which may prove fatal.

In other cases, the abdominal muscles may be ruptured, although the skin may remain unbroken. A man was admitted under my care into the Hospital having received a blow from the buffer of a railway-carriage upon his abdomen. He complained of great pain at one spot; and, on examination after death, we found the rectus muscle torn across without injury either to the integuments or the peritoneum. If the patient live, an injury of this kind is apt to be followed by atrophy of the muscular substance, and perhaps by the occurrence of a ventral hernia at a later period. Occasionally the contusion is followed by abscess in the abdominal wall, which has a tendency to extend widely between the muscular planes. The abscesses should be opened early, lest they burst into the peritoneal cavity and occasion fatal inflammation.

Buffer-Accidents.—A contusion of the abdomen is often associated with **Rupture of some of the Viscera.** In military practice these internal injuries are met with in the so-called "wind-contusions;" in civil practice they commonly result from blows, kicks, the passage of a cart-wheel over the abdomen, or a squeeze of the body between the buffers of two railway carriages. These "*Buffer-accidents*" are of common occurrence in hospital practice, resulting usually from the carelessness of railway-guards and porters, who, in trying to pass between carriages in motion, are caught and squeezed between the buffers. In these cases the most fearful internal injuries occur, often without any external wound. A man was admitted under my care into University College Hospital, in whom the liver, stomach, spleen, and kidneys, were crushed and torn; the heart was ecchymosed on its surface, and one of the lungs was lacerated, without any rupture of the skin or fracture of the ribs. The particular organ injured depends on the situation of the blow. The organ that is most frequently crushed in this way is the liver, owing to its large size and the unyielding nature and ready lacerability of its structure; the other solid organs, such as the spleen and kidneys, do not suffer so frequently: the pancreas I have never seen injured. Among the hollow organs the stomach most commonly suffers, and it is especially likely to do so if struck while distended by food. Any portion of the intestinal canal may be lacerated. I have seen the duodenum, the ileum, the jejunum, and the large

intestine ruptured in different cases: the mesentery likewise may be torn, and the spermatic cord snapped across.

The sufferer usually dies in the course of a few hours, after the receipt of these severe injuries, from hæmorrhage into the abdominal cavity, conjoined with shock. It is seldom that life is prolonged sufficiently for peritonitis to be set up, though this is the chief danger to be apprehended in those cases that survive the more immediate effects of the accident. The shock of itself may prove fatal, though there be but little apparent internal mischief; thus, I have seen a man die collapsed eight hours after a buffer-accident, in whom no injury was found except a small rupture of the mesentery, attended with but very slight extravasation of blood. The severity of the shock, amounting often to prolonged and complete collapse, is one of the most remarkable phenomena attending these injuries. It is difficult to account for it, except on the supposition that it is due to wound or concussion of the great sympathetic nerve and its large abdominal ganglia. To whatever cause it may be referred, it is certain that it is greater than that which follows a corresponding injury, unattended by loss of blood, of any other part of the body except the central portions of the cerebro-spinal nervous system. The continuance of the shock may be maintained, and its intensity increased, by the syncopal effect of internal hæmorrhage, which, when the solid organs are ruptured, is the most common cause of death. So far as my experience goes, I would say that the shock is most severe in injuries of and about the stomach, probably from damage to the great solar plexus. Hæmorrhage is the most usual cause of death when the liver and spleen are ruptured; and the patient usually dies of acute peritonitis when the intestine has been torn across.

The *Symptoms* of an internal abdominal injury are often extremely equivocal, and will necessarily vary according to the organ injured.

If the **Liver** have been ruptured, pain over the region of that organ, dulness on percussion from extravasated blood, and great collapse, followed, if the patient live, by diffuse peritonitis, bilious vomiting, white stools, and jaundice, will, with sufficient precision, indicate the true nature of the injury. Bernard has further shown that contusions of the liver are followed by saccharine diabetes.

Rupture of the liver is by no means always speedily or even necessarily fatal. It may be, and usually is so, from great extravasation of blood or of bile; but if neither of these be largely poured out, the patient may live for some considerable time, though he may eventually succumb to peritonitis. A man was once admitted under my care into the University College Hospital, who had been crushed between the buffers of two railway carriages. He was collapsed and apparently moribund, but rallied in a few hours. Two days after the accident, great pain and tenderness in the right hypochondrium were complained of, and dulness on percussion was found to extend as low as the umbilicus. He became jaundiced, and there were symptoms of low peritonitis; these were followed by great swelling of the abdomen, which became tympanitic; the peritonitis continued, and symptoms of intestinal obstruction came on, the dulness increasing, with fluctuation in the flanks. He died on the sixteenth day after the accident, and on examination no less than 240 ounces of bilious fluid, mixed with flakes of lymph, were found in the abdominal cavity; the obstruction of the bowels being dependent on the pressure of this effusion, and on the matting together of the intestines

by lymph. There was a large rent in the thick border of the liver, which was beginning to cicatrize.

Injury over the region of the liver, probably occasioning laceration of that organ, followed by peritonitis and jaundice, may be recovered from. Of this I have seen several instances in my own practice. The following is a good example. A man, about forty years of age, fell from a scaffold to the ground. In falling, he struck violently against a beam, injuring his abdomen on the right side. He was brought to the Hospital in a state of collapse, from which he slowly rallied. There was no injury but that of the abdomen, of which he complained much, more particularly over the region of the liver, which was very tense. Peritonitis speedily set in, with great tympanitic distension of the belly, vomiting of bilious matter, and the passage of colourless stools. These symptoms continued many days, and the man became jaundiced. As the tympanites subsided, it was found that there was dulness on percussion in both flanks, and that the fluid, which was evidently extravasated into the peritoneal cavity, rose to a level with the umbilicus when he lay on his left side, which he did habitually. He was treated with opium, and put on a very mild unstimulating diet. He gradually but slowly recovered, the vomiting becoming less frequent, and eventually ceasing, and the fluid in the abdomen being slowly absorbed, bile at the same time appearing in the motions ; but the tenderness over the region of the liver continued up to the time at which he left the Hospital, nearly two months after the accident. In this case the long and severe collapse, the seat of pain and injury, the peritonitis, the bilious vomitings, and the white stools, all pointed to serious injury of the liver ; and rapid intra-abdominal extravasation could only be accounted for by rupture of that organ.

If the **Spleen** have been lacerated, there will be all the effects of severe shock of the system, accompanied by those of internal hæmorrhage ; coldness, and pallor of the surface, a small and feeble pulse, anxiety of countenance, and great depression of the vital powers, with pain at the seat of injury, and dulness on percussion from extravasated blood. These symptoms usually terminate rapidly in death.

Rupture of the spleen is specially liable to occur from slight blows when that organ is enlarged as the result of exposure to a malarious climate.

If the **Kidneys** be injured, there will commonly be a frequent desire to pass urine, and this will be tinged with blood, often to a considerable extent. If the ureter become plugged by a clot there may be severe renal colic, the pain shooting down to testicle and thigh. Sometimes the bladder becomes distended with coagulated blood. After the discharge of blood ceases, the urine will become albuminous, and may continue so for a great length of time. On examining such albuminous urine under the microscope, it will generally be found to contain a few blood-corpuscles, and possibly some tube-casts, at first, perhaps, containing blood-corpuscles, and later on becoming granular. Pus and mucus, with epithelium-cells from the pelvis of the kidney, and occasionally renal epithelium may be met with later on, showing the existence of inflammation in the kidney. It is a remarkable and important practical fact that, so far as my experience goes, I have never seen albumen in the urine as the result of renal injury, unless it had been preceded by blood. The absence of blood from the urine must not, however, be taken as an indication that the kidney is not injured ; it may be so disorganized as to be totally

incapable of secreting, or the ureter being torn across no bloody urine finds its way into the bladder. A man was admitted into the Hospital under my care for a buffer-injury of the back; he passed urine untinged with blood, but after death his right kidney was found completely smashed by the blow, and there was an extensive extravasation of blood in the fat around it; here it was evident that the disorganization was so sudden and complete that no urine could find its way into the bladder. In another case, in consequence of a fall from a window, an elderly man died in the course of an hour, having struck his back and sustained several fractures of the limbs. The left kidney was ruptured in a starred manner, with extensive extravasation of blood into the tissues around it, but there was not a tinge of blood in the urine which was retained in the bladder.

Rupture of the kidney is by no means necessarily fatal. Patients have lived after exhibiting all the signs of it—the passing of bloody urine, and the presence of circumscribed peritonitis; and, when death has occurred at a later period, cicatrices have been detected in the organ. A patient was admitted under my care into the University College Hospital for a severe blow upon the back from the buffer of a railway-carriage, followed by hæmaturia and other symptoms of renal injury; on his death from pneumonia nine weeks after the accident, an extravasation of blood, with the marks of recent cicatrization, was found in the left kidney.

When the **Stomach** is ruptured the nature of the accident is usually revealed by bloody vomiting, with pain in the region of the stomach, and the most profound shock. These signs, however, do not occur in all cases. A man was admitted to the Hospital under my care, whose abdomen had been squeezed between a cart-wheel and a lamp-post; during the five hours that he lived he vomited several times, bringing up a meal which he had taken immediately before the accident. In the vomited matters there was no blood to be seen; but on examination after death it was found that not only the liver and spleen were ruptured, but the stomach was torn almost completely across near the pylorus.

Rupture of the **Intestine** is much more common than that of the stomach. It may occur at any part of the gut, but is most commonly met with in the duodenum or at the junction of the duodenum and jejunum. The frequency with which the duodenum is ruptured is due partly to its position, and partly to its fixity. The third part of the duodenum crosses the spine in front of the second lumbar vertebra, or about one inch above the umbilicus, and thus receives no protection from the costal cartilages. In this part of its course it is uncovered by peritoneum, and is consequently fixed so firmly that it receives the full force of any violent pressure, being unable to slip away from beneath it, as do those parts of the intestine which are completely covered by peritoneum, and attached to a loose mesentery. When the force is applied in an oblique direction from right to left, rupture occasionally takes place at the junction of the movable jejunum with the fixed duodenum. Rupture of the duodenum may occur therefore with or without injury to the peritoneum. Rupture of the gut into the peritoneal cavity is indicated by intense pain in the belly with severe shock. Peritonitis speedily sets in, with vomiting, at first bilious, but soon becoming dark-coloured or almost black. The abdomen becomes tympanitic and tensely distended, with gradually increasing dulness in each flank. Free gas in the peritoneal cavity may sometimes be recognized by tympanitic

resonance in front of the liver. The belly is acutely tender, and the patient lies on his back with his knees drawn up. These injuries are extremely fatal, in fact if the aperture in the gut be of sufficient size to allow of the escape of the contents of the gut into the peritoneal cavity, death almost inevitably results. Rupture of the third part of the duodenum behind the peritoneum is accompanied by much less clearly marked symptoms; there are pain and tenderness, and possibly vomiting of blood. If the patient survive sufficiently long he may pass a motion blackened by altered blood. Death takes place in these cases usually from diffuse suppuration spreading in the loose subperitoneal tissue downwards in front of the kidneys or even to the iliac fossæ, in consequence of which peritonitis with effusion is often set up.

An occasional symptom of rupture of the intestine is **Emphysema of the Abdominal Wall**, and subsequently of the trunk generally, from the escape of flatus from wounded intestine into the subperitoneal areolar tissue, and thence into the more superficial planes. When this takes place, the same doughy, puffy, inelastic, crepitating swelling of the subcutaneous areolar tissue, that is met with in thoracic emphysema, is observed. It usually commences in one or the other flank, and may then creep up towards the axilla, or in front of the abdominal wall.

As a diagnostic sign, this form of emphysema is valuable in those cases in which the intestines have been injured, either without any wound of the abdominal parietes, or, if there be wound, without protrusion of the injured portion of gut. In two of the cases in which I have observed it, this condition was the only positive sign of intestinal injury. In one case, the transverse duodenum had been ruptured where uncovered by peritoneum, by a buffer-accident; and, in the other the rectum and meso-rectum had been traversed by a pistol-ball. In both these cases the emphysema was extensive, the flatus having passed directly into the subperitoneal areolar tissue. In other cases it may in the first instance pass into the cavity of the abdomen, and render that tympanitic, and then, as in thoracic emphysema after pneumothorax, escape into the areolar tissue at the edges of the wound. In a case under my observation, it occurred after tapping the bladder through the rectum. The flatus escaped, after the removal of the cannula on the sixth day, through the small aperture in the walls of the gut into the subperitoneal areolar tissue of the pelvis, thence, through the sciatic notches, down the posterior and outer parts of the thighs and the flanks.

The diagnosis of abdominal emphysema from thoracic emphysema, and from putrefactive infiltration of air into the areolar tissue, requires to be made. In the first case, the diagnosis may readily be effected by observing an absence of the signs of thoracic injury, and by the situation of the emphysema in the posterior or lateral abdominal wall, or around the lips of a wound. From putrefactive infiltration with air, the abdominal emphysema is easily distinguished by the cause, and by the absence of diffuse inflammation of the areolar tissue.

The **Treatment** of the various injuries of the abdomen that have just been described is very simple. If the symptoms indicate laceration of one of the viscera, little can be done during the state of collapse supervening on the accident, beyond keeping the patient quiet, and employing the means that have been recommended for lessening the effects of shock. If the patient survive this period, our chief reliance must be placed on the maintenance of perfect rest

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of the intestines by the free administration of opium. The treatment of traumatic peritonitis will be more fully described with Wounds of the Intestine.

Wounds of the Diaphragm may be occasioned by stabs or by gunshot-injury. Sometimes, however, this muscle is perforated by the fragment of a broken rib without external wound. The lesion, though not in itself mortal, is necessarily usually complicated with so much visceral injury as to be very generally followed by death. If the patient survive, the aperture may be closed by a cicatrix, to which the adjacent lung will probably adhere; and thus the separation between the cavities of the chest and abdomen will be maintained. Should this not happen, a hernial protrusion of some of the abdominal viscera may take place into the pleural cavity, as will be more fully described when we speak of "Diaphragmatic Hernia."

Wounds of the Abdomen.—**Wounds of the Abdominal Wall that do not penetrate the Peritoneal Cavity,** if uncomplicated with internal injury, usually do well, and require merely to be treated on ordinary principles. If they be incised, and so extensive as to require sutures, the stitches should be introduced through the skin alone, never through muscular or tendinous structures, the union of which could not be effected in this way; the parts injured must also be relaxed by careful attention to position. When they are the result of gunshot-injury, they suppurate extensively, and are very slow in healing. The epigastric artery is occasionally divided in these injuries, and may give rise to extravasation of large quantities of blood into the sheath of the rectus; the wound must then be enlarged, if necessary, the extravasated blood cleaned out, and the artery secured by a ligature.

Wounds that Penetrate the Cavity of the Abdomen are of especial interest, on account of the frequency with which they are complicated with peritonitis, and with injury of the viscera. They may, for practical purposes, be divided into, 1, those that Penetrate the Peritoneal Sac, without wounding or causing the protrusion of any of the contained organs; and, 2, those that are complicated with Protrusion or Wound of some of the Viscera.

1. **Penetrating Wounds of the Abdomen, without Visceral Protrusion or Injury,** are often somewhat difficult to distinguish from simple wounds of the abdominal wall, though the escape of a small quantity of reddish serum may reveal the nature of the accident. In these cases the Surgeon should be careful not to push his examination too far, by probing or otherwise exploring the wound, lest he really perforate the peritoneum which was previously intact. The cavity of the peritoneum has often been perforated from front to back by bullet-wounds or sword-thrusts, without there being any sign of visceral injury. In the absence of peritonitis or other signs of mischief, the wound must be treated as a simple one of the abdominal wall, and any complication that may occur must be met in the way that will immediately be described.

2. In a **Penetrating Wound with Protrusion or Injury of Viscera,** the risk is necessarily greatly increased; here the chief danger is from peritonitis, induced either by extravasation of the intestinal contents into the peritoneal cavity, or by decomposition of the extravasated blood, or serous effusion, in the peritoneum consequent upon the communication of the cavity with the air by the external wound. This is all the more likely to occur if the wound be of such a nature that it cannot unite by the first intention, as in most gunshot-injuries. It but seldom happens that death results from

hæmorrhage in these cases, though this may, of course, occur if any of the larger vessels be injured.

Protrusion of uninjured intestine, mesentery, or omentum may take place through the wound in the abdominal wall. This protruded mass is always very large in comparison with the aperture from which it escapes, the sides of which, being overlaid by it, constrict it rather tightly, so as to form a distinct neck to the protrusion. If left unreduced, the mass speedily loses its polish and bright colour, becoming dull and livid from congestion; it then inflames and swells, and soon becomes gangrenous from the pressure exercised upon it by the sides of the aperture through which it has passed.

In many cases *the protruded intestine is wounded.* The existence of this further injury will readily be ascertained by the escape of flatus, or of the fluid contents of the gut. The characters of the wound vary, as Travers has pointed out, according to its size. If it be a mere puncture, or even an incision two or three lines in length, eversion or prolapsus of the mucous membrane will take place, so as to close it sufficiently to prevent the escape of the contents. If the aperture be above four lines in length, this plugging of it by everted mucous membrane cannot occur, and then the contents of the bowel escape; but, even in these circumstances, there will be a tendency to the protrusion of the membrane, which forms a kind of lip over the edge of the cut.

A wounded intestine which does not protrude, but remains within the abdominal cavity, exhibits the same phenomena. In these cases, however, there is the additional danger of the **extravasation of the intestinal contents** into the peritoneum. This extravasation is unquestionably one of the greatest dangers that can occur in wounds of the abdomen, inasmuch as by its irritating qualities the feculent matter gives rise to and keeps up the most intense peritonitis. It is not, however, an invariable sequence of penetrating wounds of the intestine, especially if the wound be made by a sharp instrument; and even in bullet-wounds of the gut no fæcal extravasation may take place. This was well illustrated in a case in University College Hospital of a man who was shot through the abdomen. The intestines, which contained much feculent matter, were traversed by the bullet in four places. He lived twenty-four hours, and yet no feculent extravasation took place. In another case to which I was called, that of a young gentleman who had been accidentally shot through the abdomen with the ramrod of a horse-pistol, the descending colon was cut completely across, and the small intestines perforated in two places; and yet no extravasation took place, though he survived the accident two days. Otis, however, points out in the Report of the American War, that these cases are entirely exceptional, and that in the vast majority of gunshot-wounds of the intestine, fæcal extravasation does take place, and gives rise to fatal peritonitis. That certain cases escape this danger may be due to several causes. In the first place, as we have already seen, if the wound in the gut be below a certain size, there is a natural tendency to its occlusion by eversion of the mucous membrane. In other cases again, as in the duodenum or colon, the gut may be wounded at a part that is not covered by peritoneum. Besides this, it must be borne in mind that, though in ordinary language we speak of the "cavity" of the abdomen, there is in reality no such thing; there being no empty space within the peritoneal sac, but the whole of the visceral contents of the abdomen being so closely and equably

brought into contact by the pressure of the abdominal muscles and of the diaphragm, that it requires some force for the intestinal contents to overcome this uniform support, and to insinuate themselves between the coils of contiguous portions of intestine. The influence exercised by the continuous pressure of the abdominal walls upon the intestinal contents, is well shown by the greater facility with which these escape from a portion of wounded intestine that has been protruded, than from one that is still lying within the abdomen. In the former case, fæces will escape from a much smaller aperture than in the latter, in consequence of the gut not being supported on all sides by the uniform pressure to which it is subjected within the abdomen. The close and uniform contact of the coils of intestine with each other also favours the adhesion of the wounded coil to the neighbouring parts, and thus tends either to completely prevent or to limit fæcal extravasation. In some cases also it is probable that the shock of the injury arrests for a time the peristaltic movements of the gut, and in these circumstances adhesions sufficiently firm to prevent fæcal extravasation may form within twenty-four hours. Thus, in a case under my care in University College Hospital, the patient, a young man, aged 22, cut his throat, and stabbed himself twice in the abdomen with a dinner-knife. One of these wounds divided more than a third of the circumference of the jejunum. The patient survived thirty-six hours, and at the post-mortem examination the wounded coil was found to contain blood and liquid contents, but it was adherent by firm inflammatory exudation to the neighbouring coils of intestine, and no extravasation had taken place. The patient more frequently escapes without extravasation when the great gut is wounded, than when the small intestine is perforated.

Blood is extravasated readily, as the force of the circulation is quite sufficient to overcome any resistance offered by the equable support of the abdominal walls. Extravasations of blood usually diffuse themselves amongst the intestines, and gravitate to the flanks, and to the cavity of the pelvis.

When the contents of the intestine escape into the peritoneum diffuse peritonitis most commonly results, the fæces becoming mixed with the abundant inflammatory effusion. In other cases, however, extravasations, whether of fæces or blood, if in small amount, may show but little tendency to diffuse themselves, and may become localized in the neighbourhood of the part from which they were originally poured out ; owing, in the first instance, to the surrounding pressure, and, at a later period, to the formation of adhesions between the folds of intestine and the neighbouring viscera. The existence of these extravasations may, in many cases, be recognized by dulness on percussion around the wound, by the localized swelling to which they give rise, and sometimes by their escape through the external aperture.

TRAUMATIC PERITONITIS is the great danger to be apprehended in all serious injuries of the abdomen. It occurs in two forms, the localized and diffuse. **Localized peritonitis** may follow a severe contusion, without recognizable injury to any viscus. It occurs also in cases of wound or rupture of the intestine, in which there is no extravasation of the contents of the gut, and in slight lacerations of the liver, spleen, or kidneys. Localized peritonitis is accompanied by the pathological phenomena common to all inflammation ; the vessels become engorged and exudation takes place, composed of blood-plasma, more or less pure, and migrating white corpuscles. The exudation coagulates, the fibrin and the corpuscles forming the "lymph" which glues

the contiguous surfaces of the peritoneum to each other, and the serum draining away into the cavity of the abdomen, from which it is rapidly absorbed. In these cases, in which there is no persistent source of irritation, the inflammation speedily subsides, the exudation becomes penetrated by new vessels, and finally firm bands of fibrous tissue are formed, uniting the coils of intestine or the injured viscera to each other or to the abdominal wall. In other cases again, firm adhesions may form at the circumference of the inflamed area, and the process may reach the stage of suppuration opposite the wound of the gut in consequence of a very slight escape of its contents, or the same may occur opposite a wound or laceration of one of the solid viscera. There is thus formed a collection of pus bounded by the neighbouring viscera or coils of intestine, and shut off by firm adhesions from the general cavity of the abdomen. Such a collection of pus may finally burst through the surrounding adhesions, and thus set up diffuse peritonitis, or it may make its way into one of the hollow viscera or to the skin, and be safely discharged.

The symptoms of localized peritonitis are intense pain and tenderness over the affected spot: often aggravated by movement or respiration. There is some elevation of temperature, and there may be vomiting. Should a localized collection of pus form, the tenderness and pain will remain, there will be a definite swelling and hardness to be felt at the affected part. The febrile disturbance remains unrelieved, and there may be one or more rigors. Should the pus burst through the surrounding adhesions and find its way into the general cavity of the peritoneum there will be intense sudden aggravation of the pain, followed by the symptoms of diffuse peritonitis.

Diffuse Peritonitis occurs first, as the result of extravasation of the contents of the gut, either in penetrating wounds from without or from within the gut, or from ruptures from external violence; and secondly, from decomposition of extravasated blood or inflammatory exudation in the cavity of the peritoneum. The putrefactive ferment may find its way into the cavity of the peritoneum from without by means of an external wound, or from within, from the intestine, either by rupture or perforation of its coats, or in consequence of sloughing of the wall of the gut from the violence to which it has been exposed. The experience of the operation of ovariotomy shows us that the peritoneal cavity may be opened and freely exposed to the air without any great risk of the occurrence of septic peritonitis provided that it be thoroughly cleaned and no decomposable matter be left within it. The subject has further been experimentally investigated in animals by Wegner, and the results obtained by him tend to show, that if only a portion of the peritoneum be exposed to irritation, the liquid exudation is rapidly absorbed by the healthy part of the membrane, so that the cavity is kept dry and free from putrescible matter. In rabbits it was found that a considerable quantity of simple water, or even of fluids containing septic bacteria, could be injected into the peritoneal cavity without evil results following, the fluids being rapidly absorbed and carried into the blood stream. If, however, the quantity injected was greater than could be thus rapidly disposed of, septic peritonitis invariably followed. It seems probable, therefore, that the occurrence of septic peritonitis after wounds, opening the cavity of the abdomen, whether in surgical operations or in accidents, depends to a great extent upon the amount of putrescible matter in the cavity. If from a wound of some considerable vessel a large quantity of blood is extravasated, or if in

consequence of local irritation, as from a wound or rupture of the gut with or without slight fæcal extravasation, the amount of inflammatory effusion is greater than the uninjured part of the peritoneum can rapidly absorb, the putrefactive ferment finds material upon which it can act, and decomposition and septic peritonitis follow. With a clean peritoneal cavity and little exudation the patient escapes. In injuries of the liver, peritonitis may result from the escape of bile into the cavity of the abdomen without decomposition taking place.

In a case of diffuse peritonitis the *post-mortem* examination shows excess of fluid which, in the earlier stages, is found chiefly in the most dependent parts, the cavity of the pelvis and the flanks. The intestines are reddened, and the coils are distended. In the earliest stage the peritoneal surface has lost its natural gloss to some extent, and feels greasy. When the inflammation is further advanced, lymph is found on the gut, and especially in the angles between two contiguous coils. If two coils be separated, they will be found paler in colour from mutual pressure at the points which have been in contact, and marked by a darker red line where they separate. The intestines are very slightly adherent to each other. In the most dependent parts of the cavity is a large quantity of turbid serum, mixed with shreds of coagulated exudation, or the fluid may assume the form of thin pus. It is usually very offensive, and is excessively dangerous if inoculated, giving rise to the most dangerous forms of dissecting-wound. Gas from the intestines is also frequently met with in the abdominal cavity.

The *symptoms* in these cases are pain and tenderness, at first most marked in the neighbourhood of the injury, but gradually extending to the whole abdomen, and aggravated by occasional stabbing pains. This is followed by tympanitic distension of the abdomen, from paralysis of the muscular coat of the gut, and also in some cases partly from the escape of flatus into the peritoneal cavity. The patient suffers great distress; he lies on his back with his knees drawn up to relax the abdominal muscles, and the slightest pressure causes intense agony. Occasionally, respiration is seriously interfered with by the tension of the abdomen. Vomiting is an early symptom; the contents of the stomach are brought up without straining, seeming to pump out almost without effort. As the effusion increases, there will be dulness in the flanks, shifting its position as the patient is moved, and tympanitic resonance in front. As the case advances, the vomited matter becomes dark from admixture of blood from the congested mucous membrane. Hiccup may form a troublesome symptom. The pulse is at first small, quick, and hard, often assuming a wiry, incompressible character. The temperature is at first high, reaching often 103° or 104° Fahr.; but in septic cases it usually falls rapidly before death, and may even become subnormal. There is great anxiety of countenance, and before death the extremities become cold, and the patient dies with the signs of collapse. This diffuse traumatic peritonitis will set in and run its course with great rapidity. In a case in University College Hospital already alluded to, of bullet-wound of the abdomen, the patient lived twenty-four hours. Two or three pints of serous effusion with much puriform fluid were found; and great reddening of the whole of the visceral and much of the parietal peritoneum had ensued. In another case of rupture of the ileum, the consecutive peritonitis proved fatal in about thirty hours after the accident. This extreme rapidity in its course and fatal termination, is due to the rapid absorption of

the unhealthy inflammatory products, in septic cases aggravated by the presence of the products of putrefaction; in fact many of these cases form the most marked instances of this form of blood-poisoning. The rapidity of the fatal termination is due to the great extent of the absorbing surface, and the large dose of the poison that is thus taken up in a very short time.

Prognosis of Penetrating Wounds of the Abdomen.—Penetrating wounds of the abdomen are amongst the most fatal of all injuries. In the reports of the American Civil War, thirteen cases of punctured or incised wounds without injury to viscera are recorded, with nine recoveries, and nineteen similar injuries from gunshot, with twelve recoveries. Of fourteen recorded cases of punctured or incised wounds with visceral lesion only two recovered. The recorded cases of gunshot-wound with visceral injuries amounted to 3,771, and of these only 421 recovered, and in 242 the result was unknown. In the great majority of these cases the exact visceral injury was not recorded. In seventy-nine the stomach was wounded, and of these nineteen recovered. In 653 the intestines were wounded, and of these 118 recovered; but the exact part of the gut is not specified in a large proportion of these cases. Otis, however, states that he has been unable to find a single incontestable case of bullet-wound of the small intestine in which recovery took place. On the other hand, there are good records of at least fifty-nine cases of wound of the great intestine, which terminated favourably, usually with a temporary establishment of a fæcal fistula. The liver was wounded in 173 cases, of which sixty-two recovered. Injuries of the spleen were more fatal, only two recovering out of twenty-nine cases. In seventy-eight cases the kidney was wounded, and of these twenty-six recovered. Of the 2,599 cases in which the lesion was not specified, only 186 are reported as having recovered. It is evident, therefore, that the records of the cases in which the exact injury is specified, give much too high a proportion of recoveries, the mere fact of the patient's surviving having led to a more detailed account of the injury being preserved.

Treatment.—In the treatment of penetrating wounds of the abdomen, we must consider first the management of the injured parts, and afterwards that of the consecutive peritonitis.

If the wound **have not implicated any of the abdominal viscera**, it must be carefully cleaned with a sponge moistened with an antiseptic solution, care being taken not to allow any considerable quantity of the solution to enter the abdominal cavity. It must then be closed by deep and superficial sutures, the former should be of thick carbolized silk, including the whole thickness of the abdominal wall. The patient must be placed in such a position as to relax the muscles of the abdomen. Some form of antiseptic dressing should then be applied, and the whole may be supported by a broad strip of plaster or a bandage. If the wound be of great size the abdominal cavity must be cleaned, all clots of blood being carefully removed with carbolized sponges, squeezed very dry. When antiseptics are not at hand, it is better to apply silver stitches lest the silk should absorb septic matter and become irritating. The wound may then be covered with oiled lint, or some dry absorbent dressing. The patient should have a full dose of opium; about two grains of the solid opium or a hypodermic injection of the third of a grain of morphia, after which the effect must be kept up by doses of half that amount, repeated every four or six hours. The patient must be kept perfectly quiet in bed, and no

nourishment given but iced milk, or milk and soda-water, and some cold beef-tea or essence of meat, during the first three days. The bowels should not be opened by aperient medicine, lest abdominal irritation be set up, but oleaginous enemata may be administered at the end of a week or ten days.

If **the intestine be wounded but not protruding**, the treatment will depend somewhat upon the nature and situation of the wound. If, as in punctured wounds and most bullet-wounds, we merely infer from the direction of the wound that the gut is injured it would hardly be justifiable to open up the wound in order to ascertain the extent of the injury. In such cases we must endeavour to limit the peritonitis that will ensue, and also to prevent feculent extravasation. The patient should be laid on the injured side with the wound dependent, so as to allow the fæces to escape through it, if disposed to do so. If the injury be about the umbilicus, he must lie upon his back with the knees drawn up and bent over a pillow. The skin round the wound may then be cleansed, and an absorbent antiseptic dressing applied. Opium must then be administered in the full doses already indicated, so that the system may be kept well under its influence. In these cases it is of the greatest utility in preventing extravasation of fæces, by arresting the peristaltic movement of the intestine, and thus keeping it from change of position. This arrest of the intestinal movements tends greatly also to the closure of the wound. Travers has shown experimentally, and his investigations have been confirmed by subsequent observations on the human subject, that wounds of the intestines are closed by lymph that is thrown out, not only from the contiguous peritoneal surfaces of the part actually injured, but from that of neighbouring coils; so that the aperture in the gut becomes permanently glued and attached to the structures in its vicinity. In order that this process should take place, it is necessarily of importance that the movements of the bowels be paralysed; and it is a beautiful provision of nature that the very inflammation which closes the wound, arrests that peristaltic action, the continuance of which would interfere with its agglutination to, and closure by, the neighbouring parts. Until, therefore, the necessary degree of inflammation to effect this is set up, the intestinal movements must be arrested by opium.

If the symptoms of extravasation of feculent matter into the abdomen present themselves, an attempt must be made to facilitate its escape externally. The dressing must be removed, and, should the lips of the wound have already become adherent to one another, they may be carefully separated with a probe. Should an immediate escape of feculent matter take place, a drainage-tube should be inserted to ensure a ready exit for the discharges.

In cases in which no doubt exists as to the intestine being wounded, either from the extent and nature of the wound, or from the appearance of the contents of the gut externally, it becomes a question whether, considering the hopeless nature of the case if left to itself, the wound should not be enlarged, the injured gut drawn out of the abdomen, and the hole in it closed by sutures. The opinions of Surgeons on this point are somewhat divided, and there is but little actual experience to guide us. The opinion expressed by Gross would probably meet with general acceptance, that in the case of incised wounds with evident wound of the intestine, "the duty of the Surgeon is to enlarge the abdominal orifice, to seek for the wounded tube and to sew up the cut." "In gunshot wounds no benefit would be likely to accrue from such a course of treatment, as the bowel is generally pierced in a number of places, and the

case, on this account, must, therefore, generally be fatal." Otis, the Editor of the "Surgical History of the American War," is strongly in favour of attempting in favourable cases to find the wound and sew it up. In cases in which there is reason to believe that the wound is in a part of the great intestine uncovered by peritoneum, operative interference is certainly not to be recommended.

When **a portion of intestine or of omentum has protruded**, it should be carefully cleaned with an antiseptic lotion and replaced as speedily as possible, before strangulation has occurred, which may occasion gangrene. Experience has shown that carbolic-acid-lotion (1 in 40) or dilute tincture of iodine (ʒij to Oj) exerts no injurious influence on the bowel. In replacing the protruded gut, the abdominal muscles should be relaxed by bending the thighs upon the abdomen, when the Surgeon may gradually push back the protrusion by steady pressure upon it; he must not, however, employ any force, nor any rough handling of the exposed and delicate parts; but if their return cannot readily be effected, owing to the constriction of the neck of the protrusion, the aperture through which they have escaped must be carefully enlarged in a direction upwards, by means of a probe-pointed bistoury, or a hernia-knife guided by a flat director. The incision necessary to enlarge the opening sufficiently for reduction, need not exceed half an inch in length. In replacing the protruded parts, whether by the aid of incision or not, care must be taken that they are fairly put back into the cavity of the abdomen, and not pushed up into the sheath of the rectus, or into the subserous areolar tissue lying before the peritoneum; an accident that would be fatal by allowing the constriction of the neck of the protrusion to continue unrelieved. In effecting the return, the Surgeon should not push his finger into the abdomen, but must content himself with simply replacing the protruded gut or omentum, and allowing it to remain in the immediate neighbourhood of the wound in the abdominal wall, to which it will contract adhesions; and through which its contents may escape, in the event of any sloughing taking place. After the gut has been returned, the external wound must be closed by sutures, as in a case without protrusion of the viscera. If the protrusion be inflamed, it must equally be replaced without delay; but should the intestine have become gangrenous from continued constriction and exposure, no attempt at reduction should be made, but an incision must be carried through it, so as to allow the escape of fæces, and the formation of an artificial anus.

If any difficulty be found in returning a mass of protruded omentum it may be ligatured in one or more pieces with carbolized catgut or silk, and cut off, after which the stump can easily be passed into the abdominal cavity. If the protruded omentum be gangrenous, it must be excised on a level with the peritoneum, to the aperture in which that portion lying within the abdomen will have contracted adhesions.

If **the intestine that protrudes be wounded**, the treatment of the aperture in the gut will call for special attention; and Surgeons have been somewhat divided as to the propriety of stitching it up. Scarpa and S. Cooper were opposed to this practice on the ground that it does not prevent extravasation, and that the stitches produce irritation by acting as foreign bodies. They proposed to return the wounded gut, taking care, however, to leave the aperture in it to correspond with that in the abdominal wall, so that an artificial anus might be established by the adhesion of the edges of

the openings to one another, and by that means prevent extravasation. To this practice the great objection exists, that extravasation will probably occur before there has been time for the effusion of lymph, and agglutination of the contiguous surfaces ; besides which, it is impossible to secure the necessary correspondence between the two apertures, the wounded gut being very liable to alter its position after it has been replaced. It has been found by experience also that one of the objections urged against the employment of a suture—that it cannot prevent the escape of feculent matter—is not valid. If it be properly applied, it may effectually do so, as was shown by a successful case under my care, the details of which were published in the *Lancet* for 1851. That the stitches act as sources of irritation to any extent, is also doubtful. Travers found by experiment that, when a wounded gut was sewn up, and returned into the abdomen, the sutures quickly became bridged or coated over with a thick layer of lymph, and, gradually ulcerating their way inwards, at last dropped into the cavity of the intestine, being discharged *per anum*, and leaving a firm cicatrix at the point to which they had been applied. For these various reasons, Guthrie, Travers, and other Surgeons of experience, advocated the practice of stitching up the wound in a protruding intestine in suitable cases, with which opinion I entirely agree. The treatment, however, must necessarily vary in different cases. Much must depend on the nature, cause, and extent of the wound in the gut. If it be the result of gunshot-violence or other contusing force, the simple application of a suture is not likely to be of much service ; for not only might it be difficult to bring the edges together, but they would probably not adhere to one another, nor to the abdominal wall. If, however, the wound be punctured or incised the case is different. Much will depend also upon the way in which the stitches are applied, and the material used.

The sutures should consist of carbolized catgut or of silkworm-gut, such as is used for fishing, or of strong fine sewing-silk well carbolized. They must be introduced by means of a fine round needle in such a way that the peritoneal surfaces on each side of the wound are brought into contact. It is almost needless to observe that unless the serous surfaces are brought into contact no union will take place. Two serous surfaces will readily unite if brought into good apposition, but no union can possibly take place between two mucous surfaces, or between a serous and a mucous surface. Hence, in stitching up the wounded gut, the Surgeon must carefully see that the serous surfaces are well and firmly brought together, and need not trouble himself about the other coats provided they are kept out of sight.

With the view of stitching together the serous surfaces, much ingenuity has been displayed, and many devices have been practised. The mode of application most frequently adopted in the present day is that recommended by Lembert. The needle is introduced about a quarter of an inch or a little more from the wound, and made to penetrate as far as the sub-mucous tissue ; it is then brought out again about one-sixth of an inch from the edge of the cut on the same side ; on the opposite side, it is made to enter one-sixth of an inch from the edge of the cut and brought out at a quarter of an inch from it (Figs. 343, 344). The stitches must not be more than a line apart, and the whole number required must be introduced before any are tightened. When the sutures are tightened the mucous membrane is inverted, and the serous surfaces are brought into accurate contact. This suture is easily applied in

the stomach or large intestine, but from the thinness of the coats of the small intestine it is not quite so easy of application in that part. If there is any difficulty the suture may be applied in the same way, but may be made to penetrate the whole thickness of the gut on each side, as recommended by Jobert (Fig. 345). The only objection to this is, that the stitches are apt to become irritating by absorbing the contents of the intestine. The continuous suture must never be used, as should one stitch happen to cut out the whole would become loose. When the lips of the wound have been brought into

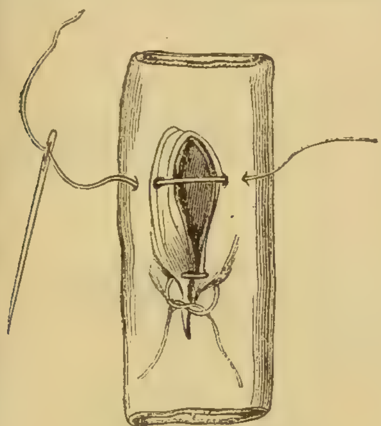


Fig. 343.—Application of Suture to Wounded Bowel.

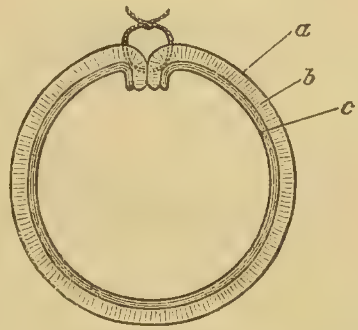


Fig. 344.—Lembert's Suture. *a*, serous; *b*, muscular; and *c*, mucous coat.

apposition, the ends of the sutures should be cut short close to the knots. If the suture be of prepared catgut it will gradually be absorbed; if it be of carbolized silk it is possible, that it may become gradually absorbed, unless it be applied so as to penetrate the mucous membrane, when it will find its way into the gut by ulceration, and be discharged from the bowel. After the aperture has been closed the intestine must be washed in lukewarm carbolized water and reduced.

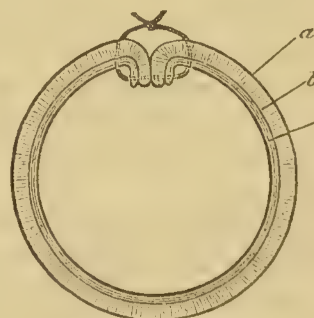


Fig. 345.—Jobert's Suture for partial division of the gut.

Should the protruded gut be completely divided, the two ends may be united to each other by the suture that has just been described. Jobert in 1822 recommended the form of suture illustrated in the accompanying diagrams (Figs. 346, 347). The lower end of the gut is to be folded in on itself, and the suture inserted as in Fig. 346; on tightening the stitches the upper end is invaginated into the lower, as in Fig. 347. The chief difficulty in this method arises in recent cases from the difficulty in clearly recognizing which is the upper and which the lower end. In old cases in which a fæcal fistula has existed, the lower end is often so contracted as to render the method impracticable.

Should the protruded gut be too extensively torn, and especially if it be lacerated by gunshot-injury, it would be useless to attempt merely to stitch it up. Three courses are then open to the Surgeon. First, the gut may be gently reduced, special care being taken not to push the wounded coil of intestine far into the abdomen, but to leave it close to the external orifice, so

that a ready outlet may be afforded to any fæcal extravasation; this method is almost inevitably fatal. Secondly, the coil being partially reduced, the edges of the opening in the gut may be fixed by suture to the margins of the external wound in the skin, and in the hopes of an artificial anus being formed, which may possibly afterwards be closed, either by the contraction of the wound or by operative proceedings at a later period; this mode of treatment is best adapted to wounds of the great intestine. Thirdly, the injured part of the gut may be cut away, and the case treated as one of complete division of the intestine. The amount of success that has attended the removal of por-

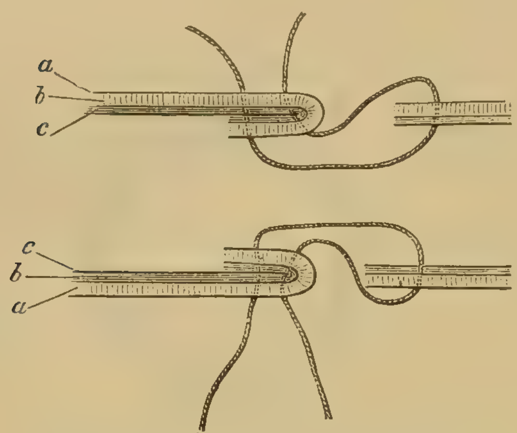


Fig. 346.—Jobert's Suture for complete Transverse Division of the Intestine. *a*, serous; *b*, muscular; *c*, mucous coat.

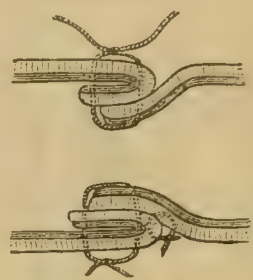


Fig. 347.—The Suture Tightened. The figure shows a Lembert's Suture introduced to give additional security.

tions of intestine for gangrene in strangulated hernia, for adhesion to abdominal tumours, and for malignant growths in the gut, and the almost hopeless nature of the case if a lacerated coil of intestine is reduced into the abdominal cavity justify the adoption of this plan in favourable cases.

In all cases in which the gut is sutured, the wound in the abdominal wall must be closed, as in cases of protrusion of uninjured viscera. Should there be any fear of fæcal extravasation, the wound may be left open, or, if extensive, partially closed, one end being left open to allow of the escape of the discharges.

During all these procedures, it is wise to adopt strict antiseptic precautions, for in no cases in surgery are these more valuable than in wounds of the peritoneum, unless it be in those of synovial membranes.

The after-treatment must be conducted in all respects on the same principles as in the case of an intestine wounded without protruding. Care must be taken, by attention to the position of the patient, and by the free administration of opium, to keep the bowel as quiet as possible near the external opening: the urine should be drawn off twice in the twenty-four hours, and no purgative whatever administered, lest, by the excitation of peristaltic action, adhesion be disturbed, and extravasation take place. After the lapse of six or eight days an enema may be thrown up, and repeated from time to time. No food should be allowed for the first three days, during which time ice and barley-water should be freely taken; after this, beef-tea, and light food that leaves no solid residue, may be given. It is of great importance that no solid food should be administered for at least two or three weeks after the occurrence of the injury.

In a case of knife-wound of the intestine which was under my care, the patient, who was progressing very favourably, and eventually recovered, nearly lost her life by eating the pulp of an orange on the tenth day.

Treatment of Traumatic Peritonitis.—In the treatment of this complication, we must be guided by the character of the inflammation. If the peritonitis be localized, leeches may be abundantly applied over the tender part of the abdomen, followed by hot fomentations, and opium must be freely administered, so as to keep the patient fully under the influence of the narcotic. Calomel may be given with the opium; a pill, composed of two grains of calomel and one grain of opium, may be administered every sixth hour, or oftener if the patient be not influenced by the narcotic; and rigid abstinence from food should be enforced, ice and barley-water alone being allowed.

In diffuse peritonitis, the result of a wound of the intestine, the calomel must be omitted, but opium freely given. Should it be apparently due to extravasation of fæces, and should there be signs of gas in the peritoneal cavity, with accumulation of fluid in the flanks, the patient will certainly die if left alone; possibly a chance of life might be given by opening up the wound and inserting a large drainage tube. Drainage is frequently adopted after the operation of ovariotomy with good effect, and there is no reason why it should not be employed in proper cases after a wound of the abdomen. When the peritonitis occurs in an old or feeble subject, our principal trust must be in the administration of opium and in leeching of the abdomen. In these cases, however, early support will be required, with perhaps the administration of wine or stimulants. The inflammatory extravasation will gradually be absorbed as the peritonitis subsides.

INJURIES OF THE PELVIC VISCERA.

BLADDER.—**Rupture of the Bladder**, from blows upon the abdomen, is not of very unfrequent occurrence. It can scarcely happen when the organ is empty, as it then sinks down under cover of the pelvic bones. But when the bladder is distended, rising above the pubes, and thinned proportionately to its distension, it may very readily be ruptured, even by slight degrees of external violence, as by one man rolling over another in a drunken scuffle, or by a person running against a post, or falling out of bed.

When the bladder is ruptured by a blow on the abdominal wall, the rent takes place always through that portion of the viscus which is covered by peritoneum. Hence there is always extravasation of urine and blood into that serous cavity. When **the bladder is wounded** by gun-shot or other injury, such as by falling on a spike, which penetrates the perineum or rectum, or by a splinter of a fractured pelvis, those anterior and inferior parts of the organ which lie outside the peritoneum may be penetrated, and thus the imminent peril of intra-peritoneal extravasation may not occur. In any case the shock following rupture of the bladder is great; but the secondary consequences will of course depend on the situation of the rupture or wound. If the laceration have occurred in those portions of the viscus that are invested by peritoneum, the urine will at once escape into the pelvic and abdominal cavities, and speedily occasion death by causing intense inflammation. If, on the other hand, that portion of the organ has been ruptured which is uncovered by the peritoneum, the urine may infiltrate the areolar tissue between this

membrane and the abdominal wall, and, diffusing widely, produce destructive sloughing of the tissues amongst which it spreads. In these cases life may be prolonged for some days, when the patient commonly sinks from absorption of septic matter from the gangrenous tissues.

The danger of a wound of the bladder is due to the effusion of continually increasing quantities of urine. It is in exact proportion to the difficulty that the extravasated urine has in finding an exit. Hence an open wound of the bladder is by no means so dangerous as a subcutaneous rupture. Many patients have recovered whose bladders have been perforated and traversed by bullets, for the urine finds a free exit through the apertures, and consequently does not tend to extravasate. Guthrie relates several cases of this kind: and Thomson saw fourteen cases after the battle of Waterloo, in a fair way of recovery. In the American War, out of one hundred and eighty-three reported cases of gunshot-wound of the bladder, eighty-seven patients survived, "though a large majority suffered from grave disabilities, and many from distressing infirmities, which resulted fatally in a few cases after years of suffering." Thus, although we may look upon this accident as of the gravest character, yet it is by no means necessarily fatal.

Symptoms.—The situation of the injury in the hypogastric region, the supervention of collapse followed by intense burning pain in the abdomen and pelvis, with inability to pass urine, or, if any have escaped from the urethra, its being tinged with blood, are usually sufficient to point to the nature of the accident. If, in addition, it be found on introducing a catheter that the bladder is contracted and empty, or that but a small quantity of bloody urine escapes, not in a uniform stream, but rising and falling with the movements of the abdominal muscles, the Surgeon may be sure that this organ has been ruptured. In the case of gunshot-injury, the escape of urine which generally takes place through the track of the bullet will afford incontestable evidence of the mischief that has been produced.

When the bladder is ruptured through that portion which is covered by peritoneum, the urine escapes into the abdominal or pelvic cavity; there, however, it does not at first diffuse very widely—remaining, under the influence of gravity, chiefly in the pelvic cavity, with the small intestines floating above it. This localized extravasation may be emptied by the catheter through the rent in the bladder, hence the escape of urine is not imcompatible with rupture of the bladder. This important practical point is well illustrated by the following case. A man was admitted into the hospital under my care, who had sustained rupture of the upper and posterior wall of the bladder by falling down stairs; when admitted he was profoundly collapsed and semi-unconscious. The abdomen was swollen, tender, tympanitic in front, dull in the flanks. On passing a catheter the bladder was found to be empty and contracted; but with a little gentle manipulation the point of the instrument could be passed through the laceration in the posterior wall of the bladder, and a large quantity of clear urine was drawn off. For two days the patient seemed to be doing well. The catheter was taken out to be cleaned, could not be introduced afterwards, little urine escaped, and the patient died of peritonitis. In another case under my care, the patient lived ten days, the bladder being kept drained.

When the bladder is ruptured through its peritoneal coat, the first and most important point in the treatment consists in drainage of the organ, so as to

prevent the continued effusion of urine and its consequences. The drainage is best effected by the introduction of a full-sized soft catheter, which must be retained and left open. Full doses of opium, as in all other abdominal lesions, should then be given, and the patient kept on low diet,—cases have in this way recovered,—or, in addition to this, the peritoneum may be injected through the catheter and washed out with carbolized water, as has been done successfully by Thorp. In one case, Walter saved his patient by making an abdominal section to allow of the escape of the extravasated urine. Willett and Heath have gone a step further by stitching up the rent in the bladder antiseptically, but without success. Erskine Mason cured a patient by lateral perineal cystotomy; and this operation would be especially indicated in those cases in which the bladder was wounded below the peritoneum.

Upon a review of the various methods of treatment that have been adopted, it appears to me that in the case of rupture of the bladder the wisest plan would be to drain by means of a large soft catheter, through which the peritoneum may be washed out antiseptically. Should this not be practicable through the urethra, then lateral perineal cystotomy should be done, with the double effect of securing perfect drainage and enabling the Surgeon to wash out freely. In all cases of sub-peritoneal wounds, free drainage through the apertures should be practised. If they are blocked, then cystotomy must be done. The constitutional treatment must be conducted on the ordinary principles that guide the Surgeon in all abdominal wounds.

Foreign Bodies, such as pieces of catheters, tobacco-pipes, pencils, &c., are occasionally met with in the male urinary organs, having been introduced through the urethra. In some cases they are soon spontaneously expelled. If left in the bladder they become encrusted with phosphates, and thus often become the nuclei of large and irregularly-shaped calculi; hence it is absolutely necessary to remove them speedily. This may occasionally be done by fortunately seizing the foreign body with a small lithotrite or urethral forceps at one end, and withdrawing it in the direction of its long axis. But if this procedure be unsuccessful, it must be cut out. This is more safely done by the median than by the lateral operation of cystotomy.

Bullets, pieces of clothing, &c., are occasionally lodged in the bladder in gun-shot-wounds of that organ. These speedily become incrusted with phosphatic deposits, and, giving rise to the symptoms of stone in the bladder, require to be removed by cystotomy, an operation that has proved very successful in these cases, evidently in consequence of the healthy condition of the urinary organs. Dixon has collected from various works the details of fifteen cases, in which balls, that had either primarily entered the bladder, or had found their way into this organ by abscess or ulceration after having been lodged in the neighbourhood, were extracted by operation. In ten of these cases the result was successful; in the remaining five no record is made of the termination. In the Surgical History of the American War, twenty-one cases are recorded in which lithotomy was performed for the extraction of foreign bodies, or traumatic calculi. Of these three died, the result in one case is unknown, and the rest recovered. In thirteen cases the missile itself was removed from the bladder; in three, a splinter of bone formed the nucleus; in one the stone had formed round a piece of cloth, and in another on a curl of hair from the pubes; in the remaining cases soft organic matter of doubtful nature formed the nucleus.

Arrow-heads also have been met with in the bladder. There is, in the Army Medical Museum at Washington, a remarkable specimen of an Indian arrow-head which formed the nucleus of a large phosphatic calculus.

In the female also, various foreign bodies are occasionally passed up the urethra, and slipping from the fingers are lost in the bladder. Hair-pins, bougies, pencils, pen-holders, and a vast variety of similar objects have here been met with. As a rule, they may easily be extracted through the urethra, which should be expanded by a proper dilator.

Rupture of the Ureter.—Stanley has related a remarkable case in which the **Ureter** was ruptured by external violence, and in which the patient recovered; a very large accumulation of fluid forming on the injured side of the abdomen, with considerable circumscribed tumefaction and fluctuation, and which required repeated tapping. In another case, in which the **Pelvis of the Kidney** was ruptured, a similar collection of urine took place within the abdomen, requiring tapping; as much as six pints being removed at one sitting. On examination after death, which occurred in the tenth week from the accident, a large cyst was found behind the peritoneum, communicating with the pelvis of the kidney.

Wounds of the Organs of Generation in the male may be accidental, occasioned by sharp instruments or gun-shot, or may be self-inflicted. When involving only the integuments, they present nothing peculiar and do not differ from similar wounds in other situations, except in the great reparative power that the scrotal and penile coverings possess. Even when the whole of the skin of the part has been cut or torn away, the organ is speedily recovered. In one curious case under my care, in which a jealous wife had unsuccessfully attempted to cut off her husband's penis with a carving-knife, the organ, which had had the whole of its integuments torn off from the root forwards, quickly became covered with a new integument, which speedily assumed the soft and supple character natural to the skin of these parts.

When the penis is more deeply wounded, there are two special sources of danger, viz., hæmorrhage, and wound of the urethra. The hæmorrhage is usually very profuse. If it proceed from a distinct arterial trunk, such as the dorsal artery or that of a corpus cavernosum, the vessel must be ligatured. If it occur from general oozing from the vascular tissues of the penis, it may be arrested by cold, pressure, or astringents. Pressure is best applied by passing a large catheter into the bladder, and then compressing the organ against this by means of a narrow bandage or circular strip of plaster.

Injury of the genital organs by self-mutilation is occasionally met with in cases of sexual mania or melancholia. In some cases the patient has cut off one testis; in others, the penis; in others, again, the whole of the external sexual organs. Injuries such as these present no very special character, and require to be treated on ordinary principles, the great point being of course to restrain the hæmorrhage and to prevent contraction of the urethral orifice.

Urethra.—**Wounds of the Urethra** by gunshot-injury, or sharp instruments, is a troublesome accident, on account of the liability to the infiltration of urine and ultimately to fistula. It may be recognized by the escape of blood from the meatus, and of urine from the wound. The *Treatment* consists in the introduction of a gum-catheter, which should be tied in; and if the edges of the wound be clean cut, they may be brought together by interrupted sutures. The catheter should not be kept in longer than is necessary. After

the first week, the patient can in many cases be taught to pass a soft instrument for himself whenever he desires to pass water.

Laceration of the Urethra is immediately attended by most serious symptoms, and remotely followed by most disastrous consequences. It very frequently occurs in men employed in building, from slipping in walking across an unfinished floor, in such a way as to fall heavily astride upon one of the joists. I have seen it in a farrier, kicked in the perinæum whilst shoeing a horse; and it is not uncommonly met with as a consequence of injury by a fragment of bone in fracture of the rami of the pubis and ischium.

In all forms of the accident it is almost invariably the membranous part of the urethra that suffers. In a violent blow in the perinæum the urethra is forcibly driven upwards, and crushed against the pubic arch. When the laceration occurs from a fragment of bone in a fracture, it is usually in those cases in which the pelvis is forcibly compressed, and gives way both behind and in front (Fig. 223). The outer fragment is driven across the middle line in the perinæum, and thus tears the urethra. In both these accidents the anterior layer of the triangular ligament is torn; it is impossible that the membranous part of the urethra could be lacerated by a blow in the perinæum while it remained intact; and in the fracture it is torn at its attachment to the pubic arch; consequently if urine escapes from the urethra it readily finds its way into the loose areolar tissue beneath the deep layer of the superficial fascia.

In these injuries the integuments are usually untorn, but deeply ecchymosed. The extravasation of blood is often considerable, extending into the scrotum, which rapidly swells up and becomes black. It may, indeed, be very serious, arising in some cases from the lacerated structures and the torn superficial or transverse arteries of the perinæum; in other instances from the corpus spongiosum, the bulb, or the artery of the bulb. In all cases of lacerated urethra, blood will drip from the orifice; and, if the bulb and its arteries have been torn, the hæmorrhage from these may be very great, a pint or more of blood being thus rapidly lost, in addition to great accumulations in the perinæum and scrotum, distending these parts with coagula.

In consequence of the interruption in the continuity of the canal and the compression or plugging of the torn part by coagula of extravasated blood, the urine cannot be voided and the bladder gradually fills. If the patient attempt to empty it, only a few drops will issue from the urethral orifice; but he will be seized with severe burning, smarting pain in the perinæum, and the ultimate evils of the injury will be greatly aggravated, for, wherever the urine penetrates, sloughing of areolar tissue will invariably and rapidly ensue. There is this great difference between extravasation of urine from ruptured bladder and from lacerated urethra: in the first case the urine escapes involuntarily from the injured organ; in the second instance, no urine will escape from the torn urethra, unless by a voluntary expulsive effort on the part of the patient. The sufferings of the patient are speedily increased by retention of urine and the distress occasioned by distension of the bladder; and the necessity for relief thus becomes urgent, lest by an involuntary spasmodic effort the urine be pumped widely into the already broken down areolar tissue of the perinæum and scrotum.

The pathology and symptoms of extravasation of urine are fully described in the Chapter on Stricture of the Urethra. (See Vol. II.)

The ultimate results of a lacerated urethra are no less serious than the immediate effects. If the floor only of the urethra have been lacerated, leaving the upper part of the wall of the canal intact, the continuity of the urethra will not be lost, but a permanent traumatic stricture of the worst kind will ensue. If the urethra have been completely torn across, or slough as a result of the injury, obliteration of a portion of the canal may take place, and an incurable urinary fistula will be left in the perinæum.

The *Treatment* consists in the early introduction of a catheter into the bladder. If this can be done before the patient has made an attempt to pass his urine, much of the immediate danger of the case may be averted, by the prevention of urinary infiltration. The catheter, which should be an elastic one, must not be too small; as a rule, No. 8, English scale, will be found the most convenient size. A catheter coudé will usually pass more readily, as the point is kept towards the roof of the canal which usually is uninjured. If this do not enter readily, an English gum-elastic catheter on a stylette bent to a proper form, various angles and curves being tried one after another, will often be successfully passed. No force must on any account be used: there is no resisting stricture to overcome; the passage is free enough if the right way in be found. When a catheter has been passed it must be left in for about a week. It should not be plugged, but should have a vulcanized India-rubber tube attached, so that the urine may escape as fast as secreted. If any hardness, throbbing, or other sign of irritation occur in the perinæum, a free incision should be made into the part, so as to afford a ready outlet for urine that may have been effused. If the Surgeon find it impossible to introduce a catheter into the bladder, the urethra being torn completely across, he should pass it as far as it will go, and then, putting the patient in the position for lithotomy, make a free incision in the mesial line upon the point of the instrument, so as to make an opening in the perinæum that will communicate with the deeper portion of the urethra; any arteries that bleed freely should be tied. He must then endeavour to pass the catheter into the bladder, through the proximal portion of the injured urethra. This is often extremely difficult. If the floor of the urethra only have been torn, it may be accomplished by keeping the point of the catheter well against the upper wall of the canal: but if the urethra have been completely torn across, it will tax all the skill of the Surgeon to direct and pass the instrument into the vesical end of the canal. An ingenious plan for overcoming the difficulty in such cases was suggested by T. P. Teale (senior), of Leeds. A director is first introduced into the proximal end of the opening in the urethra, and over it a dilator is passed: the director being then withdrawn, the catheter is readily introduced through the dilator. Should the urine become extravasated, the Surgeon must follow its course with free and deep incisions, supporting the strength of the patient at the same time by a due allowance of stimulants and nourishment. If, when the urethra is completely torn across, a catheter cannot be passed, and the urine finds a difficulty in escaping, relief not being afforded by the perinæal incision, and the bladder becoming over-distended, this organ should be tapped through the rectum, in the way that will be described when we come to speak of diseases of the urinary organs. But tapping through the rectum should not be done before the perinæal incision is made, and is scarcely ever required after.

VAGINA AND RECTUM.—**Foreign Bodies** are occasionally thrust forcibly into or impacted in the vagina or rectum. When a foreign body, such as a

stick, or a broom-handle, or the leg of a chair, is thrust forcibly up the rectum by a person falling on it, two dangers may result—extensive laceration of the sphincter ani and the perinæum, with hæmorrhage, or transfixion of the gut and wound of the peritoneum, with consecutive inflammation of that membrane, which almost invariably terminates fatally. The consequences of such an injury present nothing very special, and require to be treated on ordinary principles. If in the fall the foreign body have been forcibly thrust into the vagina, there may be injury to the bladder or peritoneum; but the most common source of danger is laceration of the labium, and free hæmorrhage from this source. I have several times seen enormous quantities of blood thus lost. This hæmorrhage is best arrested by plugging firmly with lint soaked in a solution of the perchloride of iron, and by the pressure of a bandage.

A variety of things, such as pieces of stick, glass-bottles, gallipots, tumblers, &c., have been introduced into and impacted in these canals. Their extraction is often very difficult, in consequence of the swelling of the mucous membrane over and around them, and the depth to which they have been pushed. In order to remove them, the use of lithotomy or necrosis forceps may be required. In some cases the foreign body produces ulceration into the bladder; and it has been found to transfix the wall of the canal in which it is lodged, and, by penetrating the peritoneum, has speedily occasioned death. A remarkable case of this kind occurred in my practice, in which a cedar pencil, five inches long, and cut to a point, had been forced up by the patient herself, a young woman, through the posterior wall of the vagina into the abdominal cavity. Here it transfixed two coils of the small intestine, and after being fixed there for eight months, I extracted it by an incision through the anterior abdominal wall, midway between the umbilicus and Poupart's ligament, where its point was engaged in the fascia transversalis. It had occasioned repeated attacks of peritonitis; and, after extraction, death resulted from that cause.

LACERATION OF THE PERINÆUM.—The perinæum is occasionally ruptured during parturition. The extent of the laceration varies greatly, and influences materially the ultimate issue of the case. In some cases there is merely a slight rent at the fourchette; in others, the whole perinæum has given way as far as the sphincter ani; in a third case the sphincter also is torn; and in a fourth the rent has extended into the recto-vaginal septum. The worst cases are those in which the perinæum has been torn, and the recto-vaginal septum destroyed by sloughing from prolonged pressure of the fœtal head. In such cases, the loss of soft tissues and the existence of dense cicatricial bands render complete union by operation very uncertain.

The length of time that has elapsed since the occurrence of the injury is of little consequence. It is as easy to repair a perinæum that has been lacerated for ten years, as for ten days. A very serious evil arising from ruptured perinæum is the loss of support to the pelvic viscera, and the consequent liability to prolapsus of the uterus or of the vaginal or vesical wall giving rise to irritability of the bladder. When the sphincter ani or the recto-vaginal septum has given way, incontinence of fæces forms the most troublesome symptom. The frequent escape of small quantities of semi-solid or liquid motions must not be mistaken for diarrhœa, and is often associated with the accumulation of hard fæcal matter in the upper part of the rectum and the colon. The neighbouring parts are from this cause liable to excoriation;

and not unfrequently the rectal mucous membrane becomes prolapsed or hæmorrhoidal.

The operation for the closure of ruptured perinæum is comparatively modern. Although it had been done in France by Guillemeau in the 16th century, and by Smellie in this country, little attention was paid to the subject until Rouse, in 1834, published five cases, in four of which he had effected a cure by means of the quilled suture. From that time the operation took its place in surgery, and has now been perfected and simplified by Baker Brown, Emmett, Bantock and others.

The operation may be done at two distinct periods after the occurrence of the lacerations, viz., immediately or remotely.

The **immediate** operation is done as soon as possible after the occurrence of the accident. It is performed as follows :— The patient lying in the obstetric position, the vagina is to be plugged with a sponge having a string attached. The edges of the fissure are then cleaned and brought together carefully with two or three points of suture. The sponge is then removed. The vagina must be washed out thrice daily with a tepid antiseptic solution, the best being Condy's fluid and water, or a concentrated solution of boracic acid. The urine must be drawn off regularly. The sutures may be removed at the end of a week.

The **remote operation** consists, in chronic cases, of a plastic procedure, having for its object the bringing together and the union by adhesion of the opposite sides of the rent. The difficulty of this operation will vary according to the extent of the laceration, and its prospect of success will depend on attention to several points in its performance ; but also, as is the case with most plastic procedures, on the state of the patient's health. This should be brought up to the best possible condition before the Surgeon proceeds to operate. All local irritation should be removed, piles or prolapsus ani cured, and the parts brought into as healthy a state as possible.

Operation for Ruptured Perinæum.—The operation as performed by Baker Brown is thus carried out. The bowels having been well cleared out, the patient should be placed in the position for lithotomy. The upper wall of the vagina being held out of the way by means of a "duck-billed" speculum, the edges and sides of the rent must be freely and deeply pared in a horse-shoe shape, so as leave a raw surface about an inch in width. Most Surgeons prefer the scalpel for this dissection, but some use the scissors as being more handy and followed by less bleeding. Great care must be taken not to carry the paring too far forwards so as to encroach on the nymphæ, or too contracted an outlet will be left for future parturition. Every particle of mucous membrane and integumental structure must be removed from the fissure, and if the recto-vaginal septum is implicated special care must be taken to pare the upper angle thoroughly. Any portion of these structures that may be left behind, however minute, will, of course, be an obstacle to union, and will either completely prevent it or leave a fistulous opening at its site. Brown recommended that the sphincter ani should then be freely divided, but experience has shown that this is not necessary. Three quilled sutures (Fig. 348) should then be passed deeply through the freshened side of the laceration, and the edges brought together by a few superficial interrupted sutures. The deep sutures are best introduced by long nævus-needles. The one nearest the anus should be passed first ; and if the recto-vaginal septum

be involved in the rent, it must be dipped into but not passed through the freshened surface of this part, so as to draw it well forwards and against the new perinæum. The sutures should be introduced at a distance of one inch from the cut edge, should pass about three-quarters of an inch in depth, and be brought out on the other side at the same distance from the freshened surfaces as that at which they entered. The great difficulty in this operation will be found to consist in the removal of the mucous membrane from the aperture in the recto-vaginal septum, and in bringing its edges together. In proportion to the loss of substance that has occurred, this difficulty will increase. Sometimes a narrow band, the result of some previous ineffectual attempt at union, will be found to stretch across the gap at the verge of the anus. This should not be retained, as it will be greatly in the way of the operator, and useless as far as after-union is concerned.

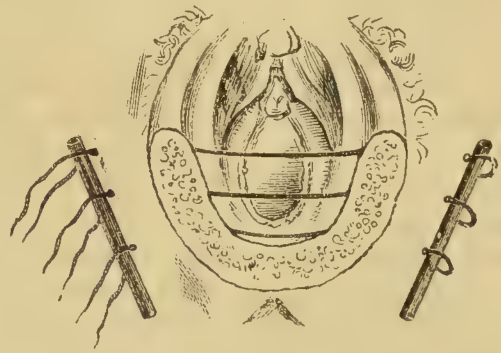


Fig. 348.—Operation for Lacerated Perinæum.

The best material for the deep sutures is thick silver wire or silkworm gut, and the simple suture is now preferred to the quilled. The superficial sutures may be of fine silver wire.

Baker Brown's method gives very good results in simple cases, but is less successful in those in which the septum is extensively torn. In these cases the operation recommended by Bantock will be found to give better results. It combines the more recent improvements of Emmett, Thomas, Le Fort and other workers in this field of Surgery, and differs in some very important respects from Baker Brown's. In the first place, the raw surface is made in the form of a wedge, being about one inch deep posteriorly, and tapering off towards the nymphæ. When the septum is torn a flap of mucous membrane a quarter of an inch or more in width is raised on each side with the base away from the middle line, both from the vaginal and rectal edges of the raw surface. A sufficient number of fine carbolized catgut-sutures are then introduced in such a way that when they are tightened they shall bring the raw surfaces of the small rectal flaps into close contact, the free edges of the flaps looking into the rectum. The deep perinæal sutures are then passed a quarter of an inch from the margin of the skin in front of the anus, carried into the recto-vaginal septum, in the middle of which it emerges, then immediately re-introduced so as to leave none visible, and brought out on the opposite side at a point corresponding to that of entry. These stitches should not be quilled, and the best material to use is strong silkworm gut (such as is used in salmon fishing). A sufficient number of fine stitches are then introduced in the vaginal flaps in the same way as has already been done in rectal flaps. The sutures are then drawn tight, beginning with those in the rectum, and ending with those in the vagina. Finally, a sufficient number of superficial interrupted stitches are introduced in the skin between the deep sutures. The ends of all the sutures are cut short. Bantock, following Marion Sims, Emmett and others, does not divide the sphincter ani. This operation has undoubtedly established an advance in the surgical treatment of ruptured perinæum. The simple or unirritating sutures are a great improvement on the quilled, which

not only occasioned much pain, but led to sloughing and consequent weak union. So also the abandonment of the division of the sphincter ani has materially lessened the severity of the operation.

Success will, to a great extent, depend on the attention bestowed on the *after-treatment*, the mode of conducting which has been laid down with much precision by B. Brown. The principal points to be attended to are the following. Immediately after the operation, a full dose of opium should be given, followed by a grain once or twice a day, so as to arrest all intestinal action. The patient should be laid on her side, and the water must be drawn off three or four times a day by means of a catheter. It is better not to tie a catheter into the bladder as it is apt to cause cystitis, and a little urine often leaks out beside it, and by dribbling over the raw edges may prevent union. All hæmorrhage should be thoroughly arrested before the surfaces are brought together ; but should any oozing occur afterwards it is best controlled by ice in the vagina. The deep sutures should not be so tight as to cause ulceration. They must be carefully looked to, and if they are causing no irritation they may be left for six days or a week. If suppuration be set up along their track they must be at once taken out. The superficial sutures may be left in for eight or ten days if they are of silver wire. The catgut stitches in the rectum and vagina do not require removal, as they ultimately melt away. Before the stitches are removed, I have found it advantageous to keep the part covered with collodion. When the stitches are removed, even if very imperfect union is found to have taken place, all hope of a cure need not be abandoned. The patient should be kept on her side and as quiet as possible, and it often happens that those parts which have not united by the first intention become soundly healed by granulation. When the sutures are removed a pad of dry lint supported by a T-bandage should be applied. When the recto-vaginal septum has been implicated, the bowels should not be allowed to act for at least ten or twelve days, lest the freshly united surfaces be torn through. They are then best relieved by a large olive oil enema. When the perinæum only has been the seat of laceration, they may be allowed to act earlier. During the whole of the treatment, the patient's strength must be supported by abundant nourishment; and scrupulous attention should be paid to the cleanliness of the parts, by frequent syringing with an antiseptic lotion, and the application of finely-carded dry wool.

Plastic operations of this kind should not be performed unless the patient be in a good state of health, that there may be a good prospect of immediate union. The success of the case will at last depend mainly on the extent of laceration, or rather of loss of substance, in the recto-vaginal septum. If this be uninjured, or merely notched as it were, there will be but little difficulty experienced in effecting a cure. If, on the other hand, this wall be deeply lacerated, or, still worse, if a portion of it have sloughed away, the greatest difficulty may result in effecting union ; and in such untoward circumstances it may happen, that the perinæum unites, but that a fistulous opening is still left in the recto-vaginal wall, requiring a future plastic operation for its closure (*vide* Chapter LXVII.).

DIVISION THIRD.

SURGICAL DISEASES.

DISEASES AFFECTING THE TISSUES GENERALLY.

CHAPTER XXX.

MORTIFICATION, OR GANGRENE.

THE death of a part of the body is, in surgical language, termed **Mortification** or **Gangrene**. In pathological language the term **Necrosis** is applied to local death generally, in whatever part or tissue it occurs; but in surgical practice it is customary to confine it to affections of the bones or cartilages: when limited to the soft tissues of a limb it is spoken of as **Sphacelation**; and when accompanied by ulceration, it is called **Sloughing**. Many other varieties of gangrene are recognized by Surgeons. Like all other diseases, it may be **Acute** or **Chronic** in its duration. As the parts affected are moist and swollen, or dry and shrivelled, it may be divided into the **Moist** and the **Dry** or **Mummified** gangrene; so again, according to its cause, it is spoken of as **Spontaneous** or **Traumatic**; and very frequently, it is arranged according to the nature of its cause under the denominations of **Constitutional** and **Local**. Besides these, various **Specific** forms of the disease are met with, which will require special consideration.

LOCAL SIGNS.—Whatever form the gangrene may assume, certain local phenomena are common to all varieties. The part becomes colder than natural, the temperature falling to that of the external air. The sensibility of the part is lost. It may be touched, pricked, or cut without feeling. In some cases the sensibility is greatly increased just before gangrene sets in, intense agonizing pain of a burning or neuralgic character being experienced, which soon gives way to complete insensibility. The natural function of the affected parts are abolished. Thus the muscles no longer contract, and all motion of the part itself ceases. It may be moved by muscles from a distance, as a mortified toe might be moved by the unaffected flexors or extensors, but it has no independent power of motion. The changes that subsequently take place in the tissues of the gangrenous part are of two kinds, giving rise to the division of gangrene into *dry* and *moist*. In the *moist* variety of gangrene death of the part takes place while the tissues are engorged with blood, either from inflammation or from obstruction to the circulation through the veins or capillaries. In this form the skin of the mortified part becomes discoloured, usually greyish or greenish, the cuticle separates, and when pressed upon obliquely slides away under the finger, leaving the moist and slippery cutis

exposed. The colour gradually darkens to a dull purplish greenish black, mottled in patches with reddish-brown spots; and after a time there is an odour of putrescence evolved, very commonly with an emphysematous crackling from evolution of gas in the tissues of the part. This shows that putrefactive changes have taken place in the solids and fluids of the tissues. The *dry* variety of gangrene occurs as a consequence of some obstruction to the supply of blood to the part, so that at the time it sets in the tissues contain less blood than natural. In it the colour is often at first of a pale tallowy-white, with a mottled appearance in parts. The skin soon shrivels, becomes dry, horny, and semi-transparent, and eventually assumes a brown wrinkled appearance; in other cases the gangrenous part is brown, dry, and shrivelled from the very first.

These characteristic signs of gangrene, although they may in some cases follow very rapidly on the loss of vitality, are in fact consecutive to it, and indicate more than the simple death of the part; they are proofs of putrescence having set in, as well as of death having occurred.

Constitutional Symptoms.—These vary greatly. When the disease is strictly local, affecting a part of but limited extent, and perhaps of no great importance to the economy, they are not very strongly marked. If, however, the gangrene, although limited, implicate important organs, as a knuckle of intestine for example, marked symptoms declare themselves.

Whatever the cause of the condition may be, the full invasion of the gangrene, if it affect any considerable extent of tissue or any important organ is always attended by great depression of the system. In such cases the countenance is dull and anxious and the pulse feeble, quick, and easily compressible; the tongue is brown, and the lips and teeth loaded with sordes. In moist gangrene the constitutional disturbance is aggravated in some cases by absorption of the products of the unhealthy inflammation from which the death of the part has resulted, and in others of the products of putrefaction from the decomposing slough. Death may in fact occur from this cause with all the symptoms of septic poisoning. In dry gangrene these symptoms are usually much less marked. When gangrene affects an internal organ the depression is always very great, and the special symptoms will vary with the part affected.

Causes.—The causes of gangrene are *predisposing* and *immediate*. Anything that tends to lower the vitality of the tissues must necessarily bring them into a state in which a comparatively slight injury may cause their death. These conditions have already been fully discussed in the chapter on inflammation (p. 159). The predisposing causes of inflammation, when acting more powerfully, predispose to gangrene.

Immediate Causes of Gangrene.—These may be divided thus:—

I. **Causes acting primarily by arrest of the Circulation.**—These may again be divided into:—

(*a.*) *Arrest of the Supply of Arterial Blood to a part.*—This is a common cause of gangrene. It may be produced by accident, or by ligature or other surgical operation, or by thrombosis or embolism of the arteries.

(*b.*) *Obstruction of the Circulation through a part.*—This is seldom a primary cause of gangrene, and as such arises only from pressure either from within, as from the growth of a tumour, or from without, as in the formation of bed-sores or sloughs beneath splints. Obstruction to the capillary circu-

lation necessarily accompanies all acute inflammations, and often forms an important element in the production of gangrene; but in inflammation it is not a primary cause, being secondary to the damage done to the tissues directly by the cause of the mischief.

(*c.*) *Obstruction to the Return of Venous Blood from a part.*—This seldom forms a sole cause of gangrene, even when important veins are occluded by thrombosis or pressure. As an accessory cause, it frequently aids in the production of gangrene, when the main artery is obstructed at the same time.

(*d.*) *Diminished Vis a Tergo from extreme weakness of the heart's action.*—This is a powerful accessory cause when there is any obstruction either to the arterial flow or to the venous return. It may result from extreme debility from fever or from starvation. The gangrene that accompanies ergot-poisoning is supposed to be due partly to relaxation of the veins by which a large quantity of blood is withdrawn from the circulation, and partly to weakness of the heart's action. Great loss of blood may in the same way aid in producing gangrene.

2. **Causes acting directly on the Tissues** :—

(*a.*) *Traumatic Causes.*—The production of gangrene by mechanical violence, heat and cold, and caustic fluids has already been fully discussed and needs no further notice here.

(*b.*) *Causes giving rise to acute inflammation.*—Any acute inflammation, as already pointed out in the chapter on inflammation, may terminate in gangrene, if the irritant which causes it is of sufficient intensity or the tissues upon which it acts are of abnormally low vitality.

In certain forms of specific infective inflammation gangrene forms the principal characteristic of the process, as in hospital gangrene, cancrum oris, carbuncle, malignant pustule, and spreading traumatic gangrene.

Amongst the causes, some are **Constitutional**, others **Local**, in their action. Those forms of gangrene are said to be *constitutional* which arise from obstruction of the circulation in consequence of disease of the heart and vessels. The constitutional state also forms frequently an important predisposing cause of gangrene in cases in which the immediate cause is local. Bright's disease and diabetes are amongst the most frequent conditions which act in this way. Those varieties of gangrene are *local* which arise from injuries of all kinds, whether applied to the part itself, or to the main artery leading to it, by its ligature or wound.

The forms of gangrene which arise from traumatic causes, have been already described in previous chapters (see pp. 318, 319) ; while those that arise from obstructed circulation to or through a part, or that take the form of specific disease, are left for consideration here.

Gangrene from Arrest of the Supply of Arterial Blood.—Whenever a part of the body is deprived of its proper supply of blood, mortification may ensue. Most commonly, when the principal trunk of an artery is obstructed, the collateral circulation is sufficient to maintain the vitality of the part ; but, should this be interfered with, gangrene occurs from the simple deprivation of blood. Indeed, the sudden loss of a large quantity of blood from the system generally may occasion the death of some of the extreme parts of the body, in which the circulation is naturally most languid. Thus Sir B. Brodie relates the case of a drunken man, who, being bled to an inordinate extent, was seized with gangrene of both feet.

Obstruction to the flow of blood through the arteries may be occasioned by two primary sets of causes :—*a*, from *injury or operation*, as wound or ligature of the main trunk ; *b*, from *disease*, as by *thrombosis* or by *embolism ;* by *calcification, and subsequent occlusion of the vessel.* Gangrene from arterial obstruction varies materially in its symptoms, prognosis, and treatment, according as it arises from one or other of these causes. When the obstruction is seated in the arteries alone, the gangrene will be of the dry kind ; but if there is also an impediment to the return of blood through the veins, the disease will partake more or less of the character of the moist variety.

a. A limb gangrenous in consequence of the **Ligature or Wound of its Main Artery**, without any other injury to the vascular system, becomes cold, feels heavy, and loses its sensibility; at the same time it assumes a dull tallowy-white colour, mottled with greyish or brownish streaks. This state of things is met with chiefly in the lower extremity. In a short time the pallid colour is lost, the part becoming brown or blackish ; the integuments of the foot become semi-transparent and horny-looking where they are stretched over the tendons of the instep, and the part presents a shrivelled appearance. This form of gangrene may invade the whole of the lower limb, but most commonly is limited to the foot, stopping either just above the ankle, or if not there, immediately below the knee, as Guthrie has observed ; the arrest taking place in one or other of these two spots, on account of the greater freedom of the collateral circulation here than in other parts of the limb. If any of the large venous trunks become obstructed or otherwise implicated, so that the return of blood through them is interfered with at the same time that the supply by the arteries is arrested, the limb generally assumes a greenish-blue colour, and rapidly runs into putrefaction. In some of these cases it happens that sloughs of the integument and subcutaneous areolar tissue form, although the limb generally preserves its vitality. The treatment of these forms of gangrene, which are strictly local, is described in the chapter on the Arrest of Arterial Hæmorrhage.

(*b.*) Gangrene may occur from the arrest of the circulation through an artery as the result of *disease of the coats of the vessel.* This is the variety that is commonly called *spontaneous.*

Spontaneous gangrene is termed **Senile** when it occurs in old people in consequence of the arteries becoming rigid and their calibre narrowed by **Atheroma or Calcification of their Coats**. The pathology of these affections of the arteries will be more fully discussed in the Chapter on Diseases of the Blood-vessels in Volume II. It is sufficient here to state that the effect of these changes is to render the arteries unable to maintain the proper circulation of blood through the limb, and further from the roughening of the inner coat to predispose to thrombosis, that is to say, to the deposit of fibrin by which the vessel may become completely obliterated. The want of a due supply of arterial blood in these cases is owing not only to the diseased state of the arteries, but also in a great measure to the weak propulsive power of the heart, and the consequent feebleness of the circulation especially through the lower limbs. When the circulation is so far interrupted as to lower the nutrition of the limb, the following premonitory symptoms are observed. A sensation of weight in the limb, with coldness, itching, and tingling in the feet, and cramps in the calves, is complained of, and the circulation of the part is habitually defective, the pulsation of the tibials being scarcely per-

ceptible. In some cases cutaneous ulcerations ensue. These symptoms commonly exist for a considerable length of time before gangrene actually comes on, and should always be looked upon with anxiety in old people. When the circulation becomes arrested from the conjoined influences of diminished cardiac power and arterial obstruction, gangrene inevitably results. It is met with in the lower extremities of people past the middle period of life, and the tendency to it increases as age advances.

Fig. 349.—Popliteal and Tibial Arteries obstructed by Thrombosis.

Senile gangrene may set in in different ways. In many instances it commences without any apparent exciting cause. The toes and foot simply shrivel, without any sign of local inflammation and with but little constitutional disturbance. The part that is destroyed becomes black, dry, and shrunken, resembling in appearance the limb of a mummy: hence the change is often termed **Mummification** (Fig. 350). The toes often look like the shrivelled skins of over-ripe or sucked-out black grapes. This form of gangrene is usually due to the complete occlusion of a previously diseased artery by thrombosis.

In other cases the gangrene is the immediate result of some slight inflammation accidentally induced, as from the excoriation produced by a tight boot, or from a trivial wound in cutting a corn or toe-nail. In these cases the slight injury, which in healthy tissues would be harmless, causes the formation of a small slough. This decomposes, and the products of putrefacton acting on the surrounding tissues, give rise to a spreading inflammation, which, owing to the greatly diminished vitality of the part, terminates in gangrene, and the process thus started may spread almost indefinitely. In other instances, again, the disease is ushered in by more acute symptoms. The whole foot becomes swollen, œdematous, and red; inflammation, apparently of a gouty character, being set up in it.

Fig 350. — Senile Gangrene: Exposure of Bones of Foot.

The gangrene may at first affect only one toe, or it may from the commencement involve several toes. It most generally begins as a purple or blackish-red spot on the side of one of the toes, usually the inner side of the great toe; this spot may be surrounded by an inflamed areola, and accompanied by much smarting and burning pain of a paroxysmal character; it spreads by gradually involving the inflamed areola, which continues to extend in proportion as the gangrene progresses. The pain, which is often of the most intense character, subsides when the gangrene becomes complete.

In whichever way the gangrene commences the affection gradually creeps up the limb, invading perhaps one toe after another, involving the instep (Fig. 350), or the sole of the foot and the heel; and unless it terminate by the formation of the line of demarcation, or death put an end to the patient's sufferings, it may extend up the ankle or leg. In other instances, the gangrene

being limited to a small extent, as to the toes only, the patient may recover with the loss of the fore part of the foot.

The constitutional symptoms vary with the mode of invasion. In the inflammatory form there is usually considerable constitutional disturbance with elevation of temperature at first, subsequently sinking into marked depression with subnormal temperature as the patient becomes poisoned by absorption of the products of putrefaction; and the disease may thus often prove fatal in from a month to six weeks. On the other hand, in the dry form of gangrene, I have known the disease to continue with very little constitutional disturbance for more than twelve months, slowly creeping on during that time. In all forms of spontaneous gangrene there is a marked improvement in the constitutional state as soon as a distinct line of demarcation forms between the dead and living tissues.

The thin skin on the anterior part of the leg at its middle and lower third is apt to fall into a state of gangrene in old people as the result of very slight injuries, and occasionally without any obvious external cause. In these cases a bleb forms which on breaking leaves a slough which gradually dries, becomes black and extends as the neighbouring pores are killed by a process of painful inflammation.

Diabetes in old people is a fertile cause of spontaneous gangrene of the toes and feet. In diabetes-gangrene the disease usually begins with a large bleb which forms on the under surface of the foot or at the end of one of the toes. This bleb contains fluid which speedily becomes turbid, and is surrounded by a dusky purple areola. From this the disease slowly spreads, and, unless the diabetes can be checked, may largely invade and destroy the foot. Should degeneration of the arterial tissues have taken place in these diabetic cases, senile gangrene of the most intractable character will ensue.

Thrombosis of an artery (Fig. 349) occurs only as a consequence of previous disease of its inner coat, so, although it is frequently the immediate cause of gangrene, by obstructing an atheromatous or otherwise diseased vessel, it is never the primary cause of the disease.

Embolism is a much more frequent cause of gangrene. An embolus is a solid body, which, having entered the circulation, is carried onwards by the blood-stream until it lodges in some vessel which is too narrow to allow it to pass. Emboli, if of any size, almost invariably lodge at the point at which a main trunk bifurcates or gives off a large branch. If very small they may pass on into the capillaries, causing capillary embolism. When an embolus has lodged in an artery, a clot forms upon it, reaching as high as the first branch above the point of obstruction. Fibrin which has been deposited upon a diseased part of a large vessel, or in a fusiform aneurism, and vegetations from the valves of the left side of the heart, form the most common sources of embolism in the systemic arteries; but occasionally a fragment of a tumour which has penetrated the coats of a large artery may be washed away into the blood-stream and form an embolus.

Gangrene from embolism is most common in the lower limb, and the bifurcation of the popliteal artery is the usual place at which the embolus lodges. If it be so small as to pass into one of the tibials, the circulation is maintained by the unobstructed artery, and gangrene does not occur. Gangrene from embolism is, however, also met with in the upper limb. In these cases the gangrene developes suddenly, the whole of the parts deprived of

blood perishing simultaneously, there being no tendency for the mischief to spread ; pulsation ceases in the terminal branches of the obstructed artery, and intense superficial pain is felt in the limb, ceasing after about a week. The limb is at first pale, but soon undergoes the characteristic changes in colour, when decomposition commences. The gangrene is always of the dry variety. In the leg, as Billroth points out, the foot soon becomes mummified, while near the line of demarcation the parts remain more moist. The line of demarcation forms in these cases immediately below the knee. Gangrene from embolism may prove fatal from septic poisoning before any attempt can be made by nature to separate the mortified part. After death, the affected vessel is found firmly plugged by the embolus, above which is a dense coagulum reaching as high as the next branch.

The accompanying drawing (Fig. 351) represents the bifurcation of the common femoral artery occupied by a fibrinous plug, taken from a man aged 32, who died of gangrene of the left leg. In this case the patient, after recovering from rheumatic endocarditis, whilst straining at stool, suddenly felt his left leg tingle painfully, then become numb and cold. The circulation in it ceased, and gangrene speedily supervened, which extended as high as the knee. Death followed amputation of the limb. Here there can be little doubt that the sudden supervention of gangrene was the result of obstruction to the arterial circulation of the lower extremity, consequent on the detachment of a vegetation from the valves of the heart, and its arrest at the bifurcation of the femoral artery.

Fig. 351.—Obstruction of Femoral Artery at its Bifurcation by an Embolus and ascending Thrombosis.

In addition to the forms of spontaneous grangrene just described, some other rarer forms are occasionally met with. Von Winiwarter has described a peculiar form of overgrowth of the endothelial cells of the inner coat of both arteries and veins (endarteritis and endophlebitis proliferans) by which their lumen becomes obliterated. Thrombi are formed in the affected vessels, and these become organized and penetrated by new vessels, as in the closure of a ligatured artery. This affection is said to be caused by syphilis and alcoholism, and occurs usually at an earlier age than ordinary senile gangrene. According to Billroth the ordinary signs of imperfect blood-supply may be present for some years before gangrene takes place. When gangrene does set in it is usually of the moist variety.

Raynaud has described a rare form of spontaneous gangrene which attacks the fingers, and sometimes the toes, symmetrically. The premonitory symptoms are that the fingers readily become "dead," often from very slight exposure to cold, and are slow in recovering. In the more advanced conditions the fingers become of a livid colour, cold and insensitive, but intensely painful, a condition described by Raynaud under the name of "local asphyxia." This may pass off after a few hours, and the circulation be restored, or a bleb may form at the end of the finger, beneath which a slough is found when the cuticle is removed, or in extreme cases the whole ungual phalanx may become mummified. The corresponding finger of the opposite hand may be affected simultaneously or at a later period. The affection is most common in women between 18 and 30. It resembles severe chilblains in some respects, but differs in the intensity of the pain, the character of the gangrene, and the age

of the patient. It is supposed to be due to vaso-motor disturbance consequent upon central mischief situated in the cord: but its pathology is not definitely made out.

Gangrene from Venous Obstruction.—Obstruction to the veins by pressure or thrombosis is scarcely ever the sole cause of gangrene; but if at the same time the main artery is occluded, as when it and the vein are compressed together, or when the femoral vein is wounded accidentally at the time when the artery is ligatured, mortification is especially apt to take place. Gangrene from this cause is always of the moist kind, attended by much œdema, with discoloration and rapid putrefaction of the part.

Gangrene from arrest of the Circulation by Strangulation.—A part is often purposely strangled by a Surgeon in operative procedures; or its circulation may in this way be arrested as the result of certain accidents or diseased conditions. (See p. 297.) In either case, the strangulation acts by stopping more or less completely the whole of the circulation through the part. If the strangulation be sufficiently severe, it may kill the tissues outright: for instance, when a nævus or a pile is tied, all flow of blood to or from the part is suddenly arrested, and its vitality is destroyed, the tissues that have been strangled shrivelling and separating by ulceration along the line of ligature. When the strangulation is not so severe as this, great congestion ensues, consequent on the amount of blood sent into the part being greater than can escape by the veins, which are more affected by the constricting force than the arteries; the part strangled becomes dark and congested, phlyctenæ or vesicles arise on its surface, and effusion takes place into its tissue. As the part swells the compression of the vessels becomes more powerful, till finally the flow through the arteries is arrested as well as that through the veins; the circulation is completely arrested, and thus sloughing arises. All this we find in the constricted gut of a strangulated hernia.

Gangrene as a termination of Inflammation.—It has already been pointed out (see the chapter on Inflammation) that all the causes of inflammation are agents which tend to lower the vitality of the parts upon which they act, and that, if acting with sufficient intensity, they bring the process of inflammation to an end by killing the tissues upon which they are exerting their influence. The effect produced by an irritant is dependent: first, on the intensity of the irritant itself; secondly, in many cases on the duration of its action; and thirdly, on the power of resistance, or, in other words, on the vitality of the tissues upon which it is acting. Thus, to take an example, a mustard plaster if applied for a short time on a healthy part causes simple inflammation without destruction of tissue; if it be of sufficient strength and be kept on a longer time, it will cause death of the skin upon which it is acting. Supposing, however, it be applied to the skin of a part, the vitality of which is lowered either by constitutional causes of mal-nutrition, such as diabetes or Bright's disease, or from local interference with nutrition, or from disease of the arteries, sloughing may result. In the chapter on Inflammation it was pointed out also that an irritant of sufficient intensity causes arrest of the circulation, by stasis, in the vessels of the part upon which it acts, and that this condition, unless relieved, must terminate in gangrene. Lastly, all acute inflammations are attended by migration of leucocytes, with abundant coagulable exudation, which distends the lymph spaces, and presses

on the vessels of the inflamed part, thus still further arresting the circulation through it. In gangrene as a termination of inflammation there are thus three causes involved: first, the direct injury done to the tissues, including the walls of the vessels, by the irritant which causes the process; secondly, obstruction to the circulation from within by stasis, and thirdly, obstruction from without by the pressure of the inflammatory exudation.

The relative part taken by these different causes varies in different forms of gangrenous inflammation. In some, the irritant that causes the process is so powerful in its action, or as it is more commonly expressed in clinical language, the intensity of the inflammation is so great as to kill the part almost directly, however healthy its texture or sound the constitution of the patient may be. More commonly, however, it is not so much the actual as the relative intensity of the inflammation that destroys the part: there being some debility, local or constitutional, by which the resisting power is lessened. Thus gangrene arises especially in persons whose tissues have become degenerate in consequence of old age, of defective food or of other materials of life, or through habitual intemperance. It is remarkable to observe what slight injuries will induce gangrenous inflammation under these circumstances. The nature of the tissue also exercises considerable influence; thus areolar tissue and fasciæ slough more readily than the skin or muscles, and the proper tissue of glands is seldom so affected. As a rule, the least vascular tissues slough most readily. The pressure of the exudation exerts a marked influence in many forms of spreading gangrenous inflammation of the areolar tissue. Thus in phlegmonous erysipelas free incisions may avert the danger of sloughing of the skin and subcutaneous tissue by relieving tension and allowing a ready exit for the inflammatory exudation.

Gangrene may form the termination of an inflammation arising from simple mechanical, physical, or chemical irritants. It is then localized, and has little tendency to spread beyond the area directly injured. It is much more frequently met with as a characteristic feature of certain forms of infective inflammation, as in phlegmonous erysipelas, sloughing phagedæna, hospital gangrene, spreading gangrene, cancrum oris, or malignant pustule. The special features of infective inflammations have been already pointed out (p. 174 *et seq.*). In the gangrenous forms of infective inflammation, death of the tissues may be due directly to the intensity of the virus, as in hospital gangrene, in which the parts are destroyed as if by the action of a powerful caustic; or to the disturbance of the circulation by the extent and abundance of the exudation, as in phlegmonous erysipelas, in which, if free vent be provided and tension relieved by incision, the death of the tissue may be prevented. Some forms of gangrenous inflammation are intensely contagious, as hospital gangrene; others, as malignant pustule, are communicable solely by inoculation; and others again, as cancrum oris, although having the characters of an infective inflammation, are not capable of being carried from one patient to another.

The *specific character* of the inflammation influences greatly the disposition to gangrene: some forms, as the carbuncular, invariably resulting in the loss of vitality of the part.

Gangrene consequent on inflammation is of the moist or acute kind, being always connected with a retention of blood in the part affected. We may

regard it as impending in a part that has become inflamed from injury or other cause, if we find that the redness becomes of a dusky or purplish hue; that bullæ filled with dark fluid rise upon the surface; that the swelling, at first hard, tense, and brawny, becomes of a pulpy or doughy character; that the pain is of a dull, heavy, or burning kind; and that the temperature of the part, at first greatly increased, gradually sinks. We know that gangrene has taken place when there is a total loss of the sensibility of the part, even to pricking or pinching; that the motion of the part itself ceases; that its colour changes to a peculiar mottled, purplish-red, or greenish-black hue, unlike anything else in the body; and that the temperature falls to a level with that of surrounding air. There is likewise an extremely offensive odour evolved, differing from that of ordinary *post mortem* decomposition.

The *Constitutional Symptoms* are always those of fever, with marked depression, often assuming the character of septic poisoning.

Arrest of Gangrene.—Certain forms of gangrene consequent upon infective inflammatory processes have a tendency to extend indefinitely until the patient succumbs to the disease. In all forms of spontaneous gangrene, and in that due to direct injury to the tissues, the progress of the mortification is in most cases arrested, and the dead parts are separated from the living. When the gangrene reaches a part of which the vitality is too great to be destroyed by the operation of the causes which have produced death in the tissues beyond, **a line of demarcation** is formed. The process by which the separation of the dead from the living tissues is accomplished has been fully described in the chapter on Ulceration (see p. 255). The dead parts are not thrown off merely by disintegration, but by a vital process, that of ulceration, occurring in the living tissues. The line of ulceration is termed the **line of separation**, and extends along the extreme margin of the living tissues (Fig. 352).

Fig. 352.—Senile Gangrene of Foot: Line of Separation.

This process of separation, commencing at the edge of the slough, slowly extends downwards to the whole depth of the gangrene; if this affect the entire thickness of the limb, the ulceration will find its way completely across it. If the slough be more superficial, the ulceration extends beneath it, and detaches it gradually. The line of separation is usually oblique, the soft parts being first divided, and the hard tissues then ulcerated through, until the ligamentous or osseous structures, which are slowly acted upon, are severed. As the ulceration extends across the limb, the largest arteries and veins are cut through by it, without the occurrence of hæmorrhage, owing to their being safely occluded by thrombosis, blocking them from the line of separation to the nearest large collateral branch above it. The period required for the detachment of gangrenous parts varies according to their extent. Small sloughs may be detached in a few days, whilst many weeks are required for the separation of a limb. The action is most rapid in soft vascular tissues and in young subjects.

After the separation of the gangrenous part, a more or less ragged irregular ulcerated surface is left, which, if not too extensive, the patient's reparative

powers being in a favourable state, will cicatrize by the same process as ordinary ulcers.

Diagnosis.—The diagnosis is easily effected when gangrene is fully developed; but in the early stages, before it is positively declared, it is not always easy to determine its existence. The ecchymosis and discolouration of a bruise, the collapse and lividity that result from cold, or the dark purple hue occasioned by long-continued congestion, may readily be confounded with impending gangrene. In these cases of doubt, the Surgeon should not be in too great a hurry to pronounce an unfavourable opinion, and still less to act upon it; for not uncommonly parts of the body which have to all appearance lost their vitality, may, under proper treatment, regain it.

Prognosis.—So far as the part itself is concerned, the prognosis is always bad; though occasionally, when gangrene has not been fully established, partial recovery may unexpectedly take place. So far as the life of the patient is at stake, much will depend on the cause of the affection, and on the age and strength of the individual; at advanced periods of life, and in a feeble state of system, the result is always unfavourable. Also whilst the gangrene is spreading, the prognosis is bad, as it is impossible to say where the morbid process may stop; but when a "line of demarcation" has formed, indicating the possession of a certain vigour of constitution, the principal danger is over, and the result will depend on the strength of the patient, and the support that can be given during the processes of separation and of repair.

Treatment.—As gangrene proceeds from a great variety of causes, it is evident that no one plan of treatment can be universally applied; and it becomes necessary to modify our therapeutical and operative means, not only according to the cause of the disease, but also with special reference to the constitution of the patient, and with regard to the stage in which we meet with the gangrene; and, indeed, it often requires great tact and experience to accommodate the treatment in this way to the varying phases of the disease.

The **Constitutional Treatment** of gangrene is of the highest importance, more especially in the spontaneous forms of the affection. It has three principal aims: 1. To *remove the cause* if possible, and thus to *arrest the gangrene.* 2. To *support the powers of the system during the process of the separation of the sloughs and dead tissues*; and 3. To *lessen the irritability of the nervous system.*

1. In attempting *to remove the constitutional cause* we must bear in mind that constitutional conditions most commonly act only as predisposing causes of gangrene, the death of the part being determined by some local affection. The constitutional conditions which predispose to gangrene, such as want of food, diabetes, Bright's disease, fevers, feebleness of the heart's action, or general arterial degeneration, are all associated with debility. Depressing remedies must therefore be avoided even in the inflammatory forms of the affection.

Inflammatory fever, however high it may be in the early stages, rapidly gives way, after gangrene has set in, to symptoms of an asthenic type. It is only before the occurrence and during the spread of gangrene, that the use of lowering remedies could possibly be suggested; for, when once gangrene has ceased to extend, however high the fever may have been that accompanied its progress, all the powers of the constitution will be required to maintain the

process of separation of the sloughs, if they be extensive and deep. Venesection is never required in any form of gangrenous inflammation. An enfeebled state of the circulation of the part of the system generally may equally occasion or complicate gangrene. In the forms of gangrene consequent upon specific infective inflammations, however acute the symptoms may be, depletion is never necessary. It would only render the tissues less able to withstand the effects of the specific irritant which is causing the process. In all inflammatory forms of gangrene the diet should at first be light but nutritious; and the patient should be put to bed, with the affected part elevated, and in many cases a brisk purgative at the commencement of the treatment enables him to take his food better. As the disease advances mild tonics may be given, and in the later periods, when the constitutional symptoms become asthenic, stimulants should be administered. The best stimulants are wine or porter, according to the patient's habits of life; and these should be given in combination with nourishment, so as not merely to raise the pulse, but to produce a more permanent tonic influence on the system generally. If much depression occur, the medicinal stimulants, especially ether, ammonia, and camphor, are of material service. The only tonics that are of much value here, are the preparations of cinchona bark and some of the vegetable bitters, as gentian and cascarilla; and though the specific virtues that were formerly attributed to them can no longer be accorded, yet when they do not irritate the stomach, they are of unquestionable service in combating the asthenic symptoms, and improving the digestive powers. In these cases I look upon cinchona bark, in combination with chlorate of potash and ammonia, as of undoubted value.

As a great part of the constitutional disturbance in most cases of gangrene is due to the absorption of the products of putrefaction from the dead tissues, much can be done to relieve the symptoms by the efficient local use of antiseptics.

2. After the proper employment of means calculated to remove the constitutional cause of the gangrene, the *system must be supported against the debilitating influences that accompany the process of ulceration and of suppuration* necessary for the separation of the mortified parts. During this period, there is less fever but more debility, and stronger tonics and stimulants can be borne; but we should be careful not to overstimulate the patient. On this point it is extremely difficult to lay down any precise rule; every possible variety as to the quantity and quality of food and stimulant being required by different individuals. The safest guides are the state of the pulse and tongue; if they improve, the means employed agree. At the same time hygienic measures should be carefully attended to; cleanliness and free ventilation, with the abundant use of disinfectants, are of the first moment.

3. The third indication, that of *lessening the irritability of the system* that always supervenes, and which is partly owing to the severity of the pain, and partly to the shaken and depressed state of the nervous system, is best carried out by the administration of opium; and although this drug may not act as a specific, as Pott supposed, yet in many cases, and especially in the gangrene of the toes and feet of old people, it is undoubtedly a remedy of the greatest value. A grain of solid opium may be administered advantageously every sixth, eighth, or twelfth hour, according to the effect which it is found to produce; care being taken that the bowels do not become confined. The

hiccup, which is often distressing, is best remedied by the administration of spirits of chloroform and camphor.

Local Treatment.—Gangrene, when threatening as the result of inflammation, may often be prevented by free incisions into the inflamed and tense tissues. Punctures are not sufficient, but free incisions two or three inches long, should be made, which by gaping widely allow the escape of blood and other fluids, and thus effectually relieve the vessels and the tissues. This is more especially the case where there is much loose areolar tissue, as in the penis or scrotum ; or indeed in any part in which much tension results from the inflammation. The *relief of local tension* is of the first importance in cases of inflammation threatening to terminate in gangrene. By a free incision through the structures so affected, as in phlegmonous erysipelas, not only may the vitality of the affected tissues be preserved, but the extension of gangrene, if it have already set in, may be arrested, and the constitutional disturbance at once lessened. By incision, also, irritating effusions and infiltrations are discharged, and thus one cause of sloughing is removed.

In the non-inflammatory form of the disease, as soon as it is evident that a part is about to become gangrenous it should be carefully washed with warm carbolic acid lotion (1 in 40). This solution is not of sufficient strength to cause any irritation of the unbroken skin. Having thus rendered the surface as far as possible aseptic, the whole limb should be thickly wrapped in salicylic wool, or it may be sprinkled with iodoform and afterwards covered with iodoform-wool. By this treatment offensive decomposition may often be prevented. Carbolic-acid-dressings should not be applied, as they are too irritating and might cause extension of the mischief. The dressing should not be disturbed unless the smell indicates that decomposition is taking place beneath it. At a later stage the same treatment may be continued, or the parts that are already gangrenous may be enveloped in lint soaked in warm solutions of carbolic acid, boracic acid, chloride of zinc, or creasote, or dusted with charcoal powder and covered with a layer of wadding. No poultices should be applied if the sloughs be large, heat and moisture hastening their decomposition ; but if they be small, yeast or charcoal poultices may be advantageously applied. *The separation of the sloughs* should be left as much as possible to nature, which is always fully able to accomplish this, if the patient's strength can be kept up. The vitality of the tissues in the proximity of and above the line of separation is very low, and may readily be destroyed by any operative interference, there being always a danger of exciting inflammation to such a degree as to cause it to run into the gangrene. Hence no attempt should be made to pull away sloughs not already separated, nor should stimulants be applied to the living tissues. It matters little as to what is done to parts already dead, which, when loosened, may be cut away ; but we must not meddle with those that are living. Hæmorrhage seldom occurs before the separation of the sloughs, but there is always danger of its happening during that process. If it occur, pressure or the actual cautery will be found the best means to arrest it ; and, if these fail, ligature of the artery higher up the limb, or amputation when practicable, might be required.

Parts that are quite dead, but that do not readily separate, such as tendons, ligaments, and bones, may be cut through with scissors, pliers, or saws, and thus many weeks or months saved in their separation. It may occasionally

be necessary in doing this to encroach on the living tissues; this should be done as carefully and as sparingly as possible, for reasons already stated.

The line of separation should be dressed with some mild antiseptic lotion or ointment, in order to keep the surface clean and to prevent the absorption of septic discharges. If sloughs do not readily separate, the balsam of Peru either pure or diluted with yolk of egg, or very dilute nitric acid and opiate lotions, are the most useful applications. After the separation of the sloughs, the ulcerated surface must be treated on general principles.

The TREATMENT OF SENILE GANGRENE, presenting some peculiarities, requires a few words to be specially devoted to it.

Constitutional Treatment.—By some Surgeons this disease has been treated on a strictly antiphlogistic plan, on the supposition that the obstruction of the arteries is caused by inflammation of their coats. Since, however, it has been clearly proved that no such process takes place, and that senile gangrene always results from chronic degenerative changes in the vessels of the limb by which the supply of blood is diminished below that necessary to maintain the vitality of the tissues, such treatment has been altogether abandoned. If blood were abstracted from the system and the action of the heart weakened, the cause of the disease would only be aggravated. But, though depletory measures are not admissible, we must guard against running into the opposite extreme, and over-stimulating patients labouring under this disease. Senile gangrene commonly occurs in individuals belonging to the wealthier classes of society, who have lived high, taken insufficient exercise, and consequently induced an irritable, plethoric, but enfeebled state of system. In many cases the patients are of a gouty habit, and occasionally the inflammation that precedes the development of the gangrene appears to be of this nature. In this condition stimulants and the more powerful tonics are not well borne; they accelerate the pulse, and interfere with digestion. As Brodie observes, it is of great importance in this disease to attend to the state of the digestive organs, in order that nutrition may go on, and that blood of a proper quality may be made. In order to accomplish this, a light nourishing diet, partly animal and partly vegetable, should be given, and a moderate quantity of wine, beer, or brandy allowed. The bowels must be relieved from time to time by a rhubarb draught or simple aperient pill. Mercury depresses the patient, and hence it should not be used as an aperient in any form in this disease, unless the state of the liver imperatively demand it. If the digestion become impaired, a stomachic, as the infusion of cascarilla or the compound infusion of gentian with a little ammonia, may be administered. The administration of opium in these cases, as originally recommended by Pott, has received the sanction of almost every practical Surgeon. Brodie's opinion on this point is especially valuable: he says, "If I am not greatly mistaken, the result of a particular case will very much depend on this—whether opium does or does not agree with the patient." From two to four grains of opium may be administered in divided doses in the course of twenty-four hours; the quantity being increased as the system becomes accustomed to its effects. If, however, it disturb the stomach and occasion headache, notwithstanding the use of aperients, as will often happen when there is febrile disturbance in persons of a full habit of body, it must be discontinued. The pain in the foot, which is often very severe during the progress of the disease, usually ceases of itself when the mortification is

complete; and before this, it is but little influenced by any sedatives, whether constitutionally or locally applied.

It may be stated generally that in those cases in which there is much fever, in which the tongue is loaded, the pulse quick, and the skin hot, in which the spread of the gangrene is preceded by a red angry blush, with much pain and heat, moderate diet and mild tonics will be most useful; whilst, on the other hand, when it is simply a shrivelling of the toes and feet, without any preceding local inflammation, or febrile disturbance, a decided tonic or stimulating plan will succeed best.

The **Local Means** to be employed in senile gangrene are simple. It is of great importance to keep up the temperature of the limb, and to encourage the flow of blood to the affected part as much as possible; this is best done by the application of salicylic or iodoform-wool, or in the absence of these, of simple cotton-wool, in thick layers around the foot and leg, so as to envelop the limb completely in this material, over which a large worsted stocking may be drawn, or a silk handkerchief stitched. This dressing need not be removed more than once or twice a week, unless there be much discharge from the line of separation, when it must be changed more frequently; the gangrenous part itself may be well powdered with iodoform, or may be simply left to dry beneath the cotton-wool. Should the gangrene be of the moist variety the dead parts may be painted with carbolic acid and glycerine (1 in 5), or some such powerful antiseptic, before being covered with wool. When the soft parts have been separated, and the bones of the foot exposed, these should be cut across by cutting pliers or a small saw, and the sores that result dressed in the ordinary way with some mild antiseptic lotion or slightly stimulating ointment. The balsam of Peru, either pure or diluted with an equal part of yolk of egg, is a very excellent application in these cases. In the event of recovery, the patient must be careful to avoid exposure to cold and to keep the legs warmly clad at all seasons of the year.

Amputation in Gangrene.—The question of Amputation in cases of gangrene of the limbs is of great importance to the practical Surgeon, and is one on certain points of which the opinions of the best practitioners still vary. At first sight it appears rational to cut off a limb that is dead, and offensive; and with propriety this may be done when the gangrene is, strictly speaking, *a local* condition, as, for instance, the result of a severe injury: any affection of the constitution in such a case being secondary to the local mischief, and dependent on absorption of the products of putrefaction from the decomposing tissues. When it arises from wounds or ligature of an artery we usually amputate at once. For the reasons which have been given (pp. 321, 444), the operation should be performed as soon as the gangrene has unequivocally manifested itself, without waiting for the line of demarcation.

There are two exceptions to the rule of amputating in traumatic and local gangrene before the occurrence of the line of demarcation; viz., gangrene from frost-bite, and that from severe burns. In these injuries it is better to wait for the formation of the line of separation, and then to fashion the stump through or just above it as the circumstances of the case require.

The question of amputation in those forms of gangrene consequent on specific infective processes, as phlegmonous erysipelas, spreading traumatic gangrene, or hospital gangrene, will be fully considered with those diseases. Such operations often give the only chance of life, but their results are on the

whole very unfavourable, the patient usually sinking from a recurrence of the disease in the stump, or from the constitutional disturbance that had previously set in.

In *spontaneous gangrene* from disease of the arteries, it is a golden rule in surgery not to amputate until the line of separation has formed; for, as it is impossible in these cases to say where the mortification will stop, the amputation might be done either too high or not high enough. It is not even sufficient in cases of this kind to wait until the line of demarcation has formed before removing the limb; these cases of spontaneous gangrene having often a tendency to remain stationary for some days, and then, creeping on, to overstep the line by which they had at first appeared to be arrested. Besides this, the local disturbance and inflammation set up by the amputation might be too great for the lessened vitality of the part, and might of itself occasion a recurrence of the gangrene. Hence in these cases it is always well to wait until the line of separation has ulcerated so deeply that there is no chance of the gangrene overleaping this barrier, at the same time that means are taken, by the administration of tonics, nourishing food, &c., to improve the patient's strength and fitness for the operation. So soon as this has been done in a satisfactory manner, and all the soft parts, except the ligaments, have been ulcerated through, the mortified part should be separated by cutting through

Fig. 353.—Spontaneous Amputation in Gangrene of Right Foot and Left Leg from Embolism.

the remaining osseous, ligamentous, or tendinous structures, and then means should be taken to fashion the stump that has been formed by nature. In some cases this will be sufficiently regular to serve every useful purpose after it has cicatrized. In most instances, however, the stump is more irregular and unsightly (a result of which the accompanying drawing (Fig. 353) is a good illustration); and the bones protrude to such an extent that it is necessary, in order to give the patient an useful limb, to amputate through the face of the stump, or higher up. All this must be left to the discretion of the Surgeon; but no procedures of this kind should be undertaken until the patient's strength has been restored sufficiently to bear the operation.

In *gangrene from embolism*, the amputation may as a rule be performed at an earlier period, provided the patient's general condition is such as to justify the operation, but it should not be undertaken until the supply of blood to the tissues immediately above the gangrenous parts is fully restored, and a good line of demarcation has formed, close to which the incisions may safely be carried.

In *senile gangrene* it has been proposed to amputate the thigh high up.

This practice has been successfully adopted by Garlike, James of Exeter, and others, and certainly appears to deserve a trial in all cases in which the health is otherwise good and the constitution tolerably sound. It has not as yet been adopted in a sufficient number of cases to warrant a positive opinion on its merits ; but it would appear that, for its success, the amputation should be done high up in the thigh, so that there may be a better chance of meeting with a healthy condition of the vessels and good vitality in the limb ; the operation being performed on the principle, that this form of gangrene is dependent on local disease obstructing the vessels of the part, and not on constitutional causes.

BED-SORES.

When a part of the body is compressed too severely, or for too long a time, even in a healthy person, it loses its vitality, and a limited slough results ; this separates, and an ulcer is left, which cicatrizes in the usual way. But in certain deranged states of the health, more especially when the blood is vitiated, and the constitutional powers lowered, as during fever, or when the heart is diseased and weakened, more particularly if the patient be old and debilitated, or if innervation be acutely affected, and he be paralysed, the skin covering those points of the body that are necessarily pressed upon in the recumbent position, such as the sacrum, the trochanters, the elbows, shoulders, and heels, becomes congested and inflamed, assuming a dull reddish-brown colour, and speedily becomes excoriated, often without any pain being felt by the patient. One great cause of bed-sores is undoubtedly bad nursing. It would not be just to say that a bed-sore is always the result of negligent nursing, but it may truly be said that the chance of the formation of bed-sores, and their severity when formed, will be increased or diminished in the exact ratio of the negligence or care of the nurse. It is not so much the actual severity of the pressure that occasions a bed-sore, as moderate long-continued pressure applied to a part congested by position in a patient enfeebled by disease or want. If means be not taken to relieve the part from the injurious compression to which it is subjected, and more especially if it be allowed to become irritated by the contact of fæces or urine, the subcutaneous areolar tissue corresponding to the inflamed patch will be converted, with the skin covering it, into a tough greyish slough, from under which a thin ichorous pus exudes. This slough may extend by a process of undermining of the integuments covering it ; and on its separation extensive mischief will be disclosed, the fascia and muscles being exposed, or the bones even laid bare, and soon becoming roughened and carious. In some cases, even the inferior aperture of the spinal canal may be laid open, and death result from septic meningitis. In other cases, the patient is worn out by discharge and irritation, or perishes from pyæmia or septicæmia.

Treatment.—This is in a great measure preventive. When a patient is likely to be confined to bed for many weeks, especially by exhausting disease, steps should be taken by proper arrangement of the pillows, and by the use of a water-bed or cushions, to prevent pressure from being injuriously exercised upon any one part. If the patient be unable to move himself his position should be changed by the nurse at regular intervals. At the same time, cleanliness and dryness should be carefully provided for by proper nursing, by the use of a draw-sheet, and furnishing the bedstead with the necessary arrangements

for using the bed-pan, &c. The back should be periodically examined by the Surgeon himself. The skin on the exposed parts may be protected by the application of collodion or soap-plaster spread upon wash-leather or amadou, or isinglass on felt; or, what is better, it may be strengthened by being washed with spirits of wine. In some cases much benefit is derived by turning the patient on his side and employing frictions of brandy and glycerine in equal parts. If the skin has become reddened it should be painted with a solution of nitrate of silver, of gr. v. to ℥j.

If the skin have become chafed, the removal of pressure is imperative, and the abrasion may be washed over with collodion. If a sore have formed, it may be dressed with the balsam of Peru, either pure or with zinc or boracic acid ointment, spread upon lint. In some cases also the prone couch may occasionally be advantageously substituted for the ordinary bed previously employed. When sloughs have formed, their separation must be facilitated by the use of moist antiseptic dressings, as boracic-acid-lint and lotion, and the ulcers that are left should be treated on ordinary principles, the utmost attention being paid to cleanliness by the use of antiseptic lotions; but no dressing that the Surgeon can apply will cause these ulcers to clean, and still less to heal, unless pressure be removed and the patient's general health improve, when they will speedily cicatrize under the most simple treatment.

BOILS.

A **Boil** is a localized inflammation affecting the skin and subcutaneous tissue terminating in the formation of a small conical slough of areolar tissue called the *core*, around which suppuration takes place, the dead tissue being finally separated and discharged by an opening through the skin. The inflammation starts in connection with a hair, but whether from the follicle itself or from the sebaceous gland is uncertain; probably it may commence in either situation. It begins as a small red pimple, through the middle of which the hair may often be seen protruding. From this the inflammation extends into the subcutaneous tissue, it is accompanied by abundant coagulable exudation, so that the inflamed area becomes raised above the surrounding parts, forming a hard circumscribed tumour of a violet or purplish-red colour, conical in form, but flattened at the top. On the summit of this a vesicle forms which bursts, leaving a grey slough exposed, which is gradually loosened by suppuration around it, and discharged usually by a single opening, after which the small cavity heals rapidly. In the early stages there are itching and tenderness, but as the tension and hardness increase it becomes extremely painful and annoying. Boils are always seated on parts provided with hair, the most common situations being the back of the neck, the shoulders, nates, and hands. They seldom occur singly, one usually following another for some weeks or even months. The nearest lymphatic glands are usually swollen, but very rarely suppurate. In some cases the inflammation subsides without sloughing or suppuration, and the boil is then said to be *blind*.

Causes.—Boils most frequently occur in young people, but are common enough at all ages. They are met with sometimes in very plethoric, and sometimes in enfeebled constitutions, often following some of the more severe febrile diseases, and attending convalescence from them; they are not uncommon in diabetic subjects. The boils which often break out during training

for athletic contests are supposed to be due to a too exclusively animal diet. Sometimes boils may be traced to exposure to sewer-gas. In other cases, the system appears to have fallen into a cachectic state, often without any evident cause, and this terminates by a critical eruption of boils. A sudden change in the habits of life, as from sedentary to active pursuits, a course of sea-bathing, &c., will also occasion them. They are commonly met with in the spring of the year, but may occur at all seasons, and are occasionally epidemic.

Local irritation is also a common cause, as in the case of boils on the hands from the contact of decomposing animal matter in *post mortem* examinations, or on the nates from the friction in rowing.

Treatment.—The **Constitutional Condition**, on which the disease is dependent, requires to be carefully attended to. No one remedy is capable of curing boils. The disease is the result, in some cases, of fault or defect in nutrition ; and the gradual modification and improvement of those processes that are subservient to it are necessary before the local affection will cease to appear. In other instances, it appears to be due to want of proper elimination of effete materials. Hence less is often to be expected from medicines in these cases, than from a general regulation of the hygienic condition of the patient. Nature will do more for his recovery than art ; and the utmost that the practitioner can do is to administer such remedies as will assist in the improvement of the constitutional condition. If it be debilitated and cachectic, iron, quinine, sarsaparilla, and cod-liver oil ; if it be plethoric, and the system loaded, purgatives, salines, and liquor potassæ will be appropriate. In the one case an abundant nourishing diet, in the other case a spare and simple one, with avoidance of stimulants, will be required. In some cases empirical means are of service. Thus, when the disease is associated with pompholyx, or preceded by painful vesicles, arsenic may be of benefit. In other instances, yeast or charcoal has been advantageously given. Ringer strongly recommends the administration of sulphide of calcium both for preventing the formation of fresh boils and hastening the separation of the slough in those that have already appeared. A tenth of a grain may be given hourly or every two or three hours.

The *Local Treatment* is simple. When the boil is in its earliest stage, if a hair can be seen projecting through the pimple, it should be pulled out with forceps. The development may in some cases be arrested also by touching it with nitrate of silver, or with a saturated solution of perchloride of mercury. When the boil is evidently forming the red area around it should be painted with equal parts of glycerine and belladonna. This usually relieves the pain and protects the skin from the irritation of the poultices or other applications. Hot, moist applications must then be employed ; four layers of wet boracic-acid-lint covered with oiled silk and cotton-wool, or a linseed-meal-poultice well greased on the surface, forms the best application. Poultices, however, in many cases irritate the surrounding skin, and encourage the formation of a fresh crop of boils. Nothing will be found to give so much relief or to hasten suppuration more than the application of a sponge squeezed out of water, as hot as the patient can bear it, and changed every few minutes. If the patient is confined to the house, he can carry out this treatment himself for several hours during the day. Most commonly a boil may be allowed to break, but the Surgeon may in some cases find it necessary to open it by a crucial

incision when it is large, and does not appear disposed to break of itself.

CARBUNCLE.

A **Carbuncle** consists essentially of a specific spreading inflammation of the subcutaneous areolar tissue, implicating the skin and terminating in death of the affected tissues, with the formation of a pulpy greyish or ash-coloured slough. Whether it commences in the deep layers of the true skin, possibly in the sebaceous glands, or in the subcutaneous areolar tissue, has not been definitely determined.

SIGNS.—A carbuncle begins as a flat or very slightly conical inflammatory swelling of the skin, the base of which is hard, and the edges clearly defined; it is of a dusky-red colour and accompanied from the first by a burning, stinging, heavy, or throbbing pain in the part, out of proportion to the apparent gravity of the disease. The inflamed base steadily enlarges and implicates the subcutaneous tissue more deeply, forming a flat, slightly elevated, hard, circumscribed swelling, gradually becoming doughy as sloughing sets in. As it increases in size, the swelling maintains its flattened circular shape, and the skin covering it assumes a purple or brownish-red tint. Vesicles form on it at several points, which speedily become pustular and burst, exposing openings beneath in the cutis, through which the ash-grey sloughs appear, and from which unhealthy purulent discharge scantily issues. The openings in the thin undermined skin gradually melt into each other, and the slough slowly separates. In most cases, the whole thickness of the subcutaneous fat is not destroyed; but occasionally when the slough comes away the deep fascia or even the muscles may be exposed.

The size of the swelling varies from one to six inches in diameter; most commonly it is about two inches across. Carbuncles are generally met with on the posterior part of the trunk, more especially about the shoulders and the nape of the neck; being rarely seen anteriorly, or on the extremities. I have, however, had to treat very large carbuncles on the abdomen, and have met with them on the shin, forearm, and forehead.

A carbuncle is almost invariably single; but some years ago I had under my care a patient on whom a large carbuncle was followed by the appearance of about a dozen smaller ones scattered over the back, in spite of which he finally recovered.

The **Constitutional Disturbance** attending this disease is always of the asthenic type; the complexion is often peculiarly sallow or yellow, the pulse feeble, and the tongue loaded; and if the carbuncle be large, or be seated on the head, death may take place, the patient frequently sinking from septicæmia or pyæmia.

CAUSES.—A carbuncle arises usually without any assignable local exciting cause; but in some cases it is evidently occasioned by the introduction of some poisonous matter into a puncture in the skin or into a hair-follicle. In all cases it is associated with and dependent upon a disordered state of the constitution. Any condition that lowers the powers of the system will predispose to, and may at last occasion, carbuncle. Habitually bad and insufficient food, the exhaustion induced by chronic wasting diseases, especially diabetes, or the debility resulting from acute febrile disease—more particularly typhus—may all occasion it. Carbuncles are more common in

men than in women, and in the old than in the young, being very rare under twenty. They occur more frequently in some years than in others.

Diagnosis.—Carbuncle resembles *boil* in many points, yet differs in its greater size, in the dusky-red of the inflamed integument, in its broad flat character, and in the large quantity of contained slough in proportion to the small amount of purulent discharge in the numerous openings on the surface, as well as in the conditions in which it generally occurs. It differs from boil also in its tendency to spread. A boil "comes to a head," bursts, and discharges pus and slough; a carbuncle will be discharging and sloughing at one part, whilst it spreads, hard and brawny, at another. A carbuncle is almost invariably single, boils most commonly appear in crops.

The Prognosis in carbuncle will depend on its size and situation, and on the state of the patient's constitution, more particularly on that of his kidneys. The most dangerous carbuncles are those that are large, and situated or encroaching on the scalp; in fact, the more this structure is involved the greater the danger. If the constitution be good, even these may be recovered from; but if the kidneys be unsound, or if there be saccharine diabetes, the progress of the disease cannot readily be checked, and the patient will usually sink.

Treatment.—The **Constitutional Treatment of carbuncle** must be conducted on ordinary medical principles, guided by the constitutional state that underlies the local disease, or that accompanies it. If the carbuncle occur in diabetic or otherwise debilitated persons, the tincture of the perchloride of iron in small and frequent doses, with a moderate allowance of alcoholic stimulants and a good diet, will be necessary. If the carbuncle occur in a person of advanced years addicted to high living, and possibly not temperate in habits, the ordinary treatment of inflammation of a low and sloughing character must be adopted. The bowels having been freely cleared out, ammonia and bark, or quinine, must be given. Alcoholic stimulants may be more freely administered. But in these they must be administered medicinally in measured quantities, and at intervals of longer or shorter duration according to the need of the patient as determined by the pulse and temperature. Port-wine used to be the favourite remedy. It is considered less necessary at the present day than it was a generation or two back, and brandy or whiskey with milk or eggs are commonly substituted for it. But whatever stimulant be given, too much care cannot be taken in regulating its doses and times of administration, which must not be left to the discretion of the non-medical attendant. In addition to stimulants, good and abundant nourishment should be given; meat, if the patient can digest it; if not, soups, such as strong beef-tea, essence of meat, or turtle-soup.

Local Treatment.—In the very early stage the progress of a carbuncle may be arrested by destroying it with a pointed stick of potassa cum calce. If the carbuncle have attained a somewhat larger size, though still small, it may be covered with a piece of soap-plaster spread on leather, having a hole cut in the centre, through which the pus and sloughy matters may be discharged. When the carbuncle is of larger size the question will arise whether it should be incised or not; and, if incised, in what way the operation should be practised. Some Surgeons uniformly adopt incisions: others, with equal constancy, reject them. I think that the exclusive adoption of either method is erroneous, and that the most successful treatment consists in allowing the question of early

incision to be determined by the amount of tension existing in and around the carbuncle. Should the parts be soft, relaxed, and comparatively painless, no advantage can result from incision; but, on the other hand, if the tension be considerable, the agony great, and the constitutional disturbance dependent on both proportionately intense, nothing gives such immediate relief, local and constitutional, as early and free incision. This may be done in two ways; either subcutaneously, by entering a long bistoury at one side of the carbuncle, and making two or three subcutaneous sweeps through the inflamed tissues in planes of different depths; or by a free crucial cut, carried fairly through the diseased parts into the healthy tissues beyond them. By either method the constitutional disturbance accompanying and resulting from the extreme tension is at once removed, the local progress of the disease is checked, and extension of sloughing by strangulation of the tissues is prevented. Should incision of the carbuncle not have been performed early, it may become necessary at a later period, in order to prevent the confinement of the pus and slough. Pyæmia is so frequent a cause of death in bad cases of carbuncle, that it becomes very important to prevent putrefaction in the sloughs. If an incision be made before the skin has given way, it should be done with antiseptic precautions. The surrounding skin should be washed with carbolic lotion, and as soon as the cut has been made some efficient form of antiseptic dressing should be applied. At subsequent dressings the surface must be irrigated with carbolic lotion. Iodoform sprinkled on the sore is a most useful antiseptic. Ordinary poultices should be avoided as tending to encourage putrefaction. The old port-wine poultice is useful and not liable to decompose. If warmth and moisture are required, a thick layer of boracic-acid-lint wetted with a concentrated solution of boracic acid will be found the most convenient application; or if this be not at hand, the carbuncle may be covered by some lint soaked in carbolic oil (1 in 10), or terebene and oil, or some other antiseptic dressing, over which a poultice may be applied. As the sloughs loosen, they should be separated; and the granulating surface which is left, and which will usually be found to be sluggish in its action, should be dressed with some of the more stimulating ointments, such as those of elemi or resin, or with the balsam of Peru. The ulcer, though large, will when thus treated cicatrize rapidly, and will leave but a small scar.

Facial Carbuncle.—Under this name has been described by Ludlow, T. Smith and others, a somewhat rare form of gangrenous inflammation of the face. It appears first as a pustule or vesicle on the lip—according to T. Smith, most commonly on the upper lip. It is surrounded by a red blush, and the tissues beneath are swollen and œdematous. The swelling spreads rapidly, often involving a great part of one side of the face; in a few days its edge is less clearly defined, and the swollen tissues are more œdematous and less brawny than in a common carbuncle. Suppuration takes place after two or three days, in patches scattered through the swollen tissues. The skin in the central part becomes dusky in colour, and the subcutaneous tissue breaks down into soft shreddy sloughs soaked in pus. The constitutional symptoms are of the gravest kind: there is considerable elevation of temperature at first, with dry tongue and great prostration. Should the patient survive to the period of sloughing and suppuration, death may take place from pyæmia or septicæmia.

The fatal result is preceded by rigors, and is evidently due to blood-poisoning of a rapid and aggravated character. The infection of the blood takes

place through the large venous anastomoses of the side of the face, which are peculiarly patent, owing to the dense areolar and fibro-cellular structures in which they ramify. The exact relation of this affection to true carbuncle is doubtful. T. Smith believes it to differ only in the greater acuteness and intensity of the process, while Paget considers the "disease so unlike carbuncle that it ought not to be known under the same name." I do not think it can be considered a carbuncular inflammation. Its whole course and the appearance of the inflamed part rather indicate its alliance to phlegmonous erysipelas. Death ensues usually in from forty-eight hours to five or six days after invasion. It is a very grave, but not a hopeless affection.

Diagnosis.—The disease somewhat resembles malignant pustule, with which it has often been confounded. The black slough surrounded by vesicles which is so characteristic of the latter disease, is, however, wanting in facial carbuncle. Moreover, in malignant pustule the slough is dry, while in facial carbuncle it is soaked in pus.

Treatment.—Abundance of liquid nourishment and stimulant are required, and Sir James Paget recommends the administration of quinine in large doses. Locally, incisions seem to have been of but little use ; the application of hot fomentations, followed by antiseptic dressings when sloughing has taken place, is all that can be done in most cases.

CANCRUM ORIS, OR NOMA.

Cancrum oris is a rapidly spreading gangrenous inflammation attacking the inside of the cheek, most frequently between the second and sixth years of life. It is met with usually in ill-fed, sickly children who have been living under bad hygienic conditions. It commonly occurs during convalescence from some acute specific fever, most frequently measles; or after the incautious administration of mercury during a weak state of the system.

Symptoms.—One of the cheeks becomes swollen, brawny, tense, and shining, being excessively hard, and presenting a dusky red patch in its centre. It is often difficult to open the mouth ; but if the Surgeon can gain a view of its inside, he will see a deep and excavated foul ulcer opposite to the centre of the external swelling, covered with a brown pulpy slough. The gums are turgid, dark, and ulcerated ; the saliva is mixed with putrescent matters ; and, as the ulceration in the mouth extends, the swelling sloughs, and a large gangrenous cavity is formed, opening externally through the cheek and internally laying bare the alveolar borders of the jaw. The child suffers little, but, as the disease advances, it commonly becomes drowsy, and at last dies comatose. This affection is most fatal. Rilliet and Barthez state that not more than one in twenty cases recovers. Should recovery take place, a large portion of the cheek may be lost, opening the mouth half way back to the ear, or a dense cicatricial band may form between the jaws, making it impossible to open the mouth.

Treatment.—The child must be put under chloroform, and the sloughing mass deeply cauterized with nitric acid, but not with the actual cautery, lest the cheek be destroyed ; the mouth should be syringed out with diluted Condy's fluid, and the ulcerating surface dusted with iodoform. The strength must be supported with beef-tea, wine, and ammonia. If recovery take place, some plastic operation may be necessary at a later period, in order either to close the gap in the cheek or to enable the child to open its mouth.

CHAPTER XXXI.

DISEASES ARISING FROM SEPTIC AND INFECTIVE PROCESSES IN WOUNDS.

This group of diseases, including septicæmia, pyæmia, erysipelas, hospital gangrene and some others of less importance, have been investigated during the last twenty years by numberless observers with an energy and ability probably never exceeded in any branch of science. As the means of observation have been improved and new methods of investigation have been invented, so the conviction in the minds of the majority of pathologists has become more and more confirmed that all these unhealthy processes are directly caused by the action of microscopic fungi. We are still very far from knowing all the conditions which, as predisposing or accessory causes, take part in the development of these diseases, or the exact mode in which the fungi give rise to the various morbid processes with which they are associated; but that their relation to them is, in some forms of disease at least, actually one of cause and effect, may be said to be no longer a mere hypothesis.

The relations of microscopic organisms to unhealthy inflammations, and the nature of a true infective process have already been discussed in the chapter on Inflammation (p. 164 *et seq.*).

It will be remembered that it was there pointed out that a clear distinction must be drawn between simple putrefaction and infective processes. Simple putrefaction is a fermentative change taking place in dead matter only, and the products of the fermentation may excite inflammation and suppuration locally, and if absorbed give rise to a definite constitutional disturbance; but the organized ferment which determines the process cannot act on living tissues, consequently there is no true infection, either locally or of the system in general. It is to processes of this kind that the term "septic" should be limited, the word then being synonymous with "putrid."

In a true infective process the virus infects the living tissues, increasing in quantity amongst them, and gives rise to unhealthy processes in them. These may be local, the accompanying constitutional disturbance being merely the result of the absorption of the unhealthy inflammatory products, or general, when the virus enters the blood stream and multiplies in it. The former is called a *local*, and the latter a *general infective process*.

In simple septic processes the fungi which are supposed to cause them are said to be non-pathogenic or non-parasitic; in infective processes they are spoken of as pathogenic or parasitic. The term "mycosis" is often used to signify the infection of the living tissues by fungoid organisms.

Although these septic and infective processes are distinct from each other, they are nearly related; infective processes very rarely starting from wounds, unless the discharges are in a septic condition. This fact has been explained by supposing that non-pathogenic organisms may develop pathogenic pro-

perties when growing in a suitable medium, such as the discharges of an unhealthy wound are assumed to be. Evidence is, however, wanting to prove this assumption. The more generally received opinion is that the specific infective processes are each due to a specific form of organism, and that putrefaction serves only as a predisposing cause of infection: first by exciting inflammation and suppuration, and thus providing a suitable medium—the inflammatory exudation or pus—in which the pathogenic fungi may develop; and secondly, by lowering the vitality of the tissues, in consequence of which they are more readily invaded by the pathogenic or parasitic fungi.

However this may be, the practical fact remains that the prevention of putrefaction is also the most certain means of preventing infection.

The mode of entrance of the virus has already been discussed (p. 166). In infective processes attacking wounds there is no doubt that in the great majority of cases, so great in fact that we may almost say in all cases, the virus enters the wound directly from without, and the surest means of prevention are those directed to protect the wound from external influences.

The local and general affections consequent upon septic processes in or infection of wounds may be thus briefly classified.

I. **The Effects of Putrefaction.—True Septic Processes.**—The poison is generated solely in dead matter, and is associated with the presence of rod-shaped organisms.

1. **Local.**—*Septic inflammation and suppuration* dependent on the local irritation caused by the chemical products of putrefaction. It is a non-infective process (p. 163).

2. **General.**—A febrile affection dependent upon the absorption of the chemical products of putrefaction from the wound. It is a non-infective process, and varies in intensity with the dose of the poison. If the dose be small and the period during which absorption lasts is short, the resulting affection is known as *Septic Traumatic Fever* (p. 179); if the dose be small and absorption continues for months, it gives rise to *Hectic Fever* (p. 230). If the dose be very large and rapidly absorbed it may be speedily fatal, the affection then forming one variety of septicæmia—*Septic Poisoning*—or *Septic Intoxication.*

2. **Infective Processes.**

1. Local processes leading to a spreading destruction of the affected tissues.

1. **Wound-diphtheria.**—This name has been applied by the Germans to a superficial infective process usually attacking granulating sores. The surface becomes covered with an opaque tough membranous layer, beneath which progressive destruction of the granulations takes place. There is febrile disturbance, but no specific constitutional affection accompanying it. It is contagious, and is associated with the growth of micrococci.

2. **Hospital-Gangrene.**—A rapidly spreading gangrenous inflammation, attacking recent or granulating wounds. The gangrene follows closely on the inflammation, the dead tissues forming a pulpy adherent slough. There is febrile disturbance, but no specific infection of the whole system. It is associated with the growth of micrococci, and is intensely contagious.

3. **Spreading Traumatic Gangrene.**—An acute rapidly spreading inflammation terminating in death of the affected tissues. The inflammation extends a considerable distance beyond the dead tissues, and the gangrenous process is accompanied by the evolution of gas and offensive decomposition. There is

constitutional disturbance of the type of septic poisoning, but there is no evidence of a general specific infection of the blood. It is associated with the presence of rod-shaped organisms, but is not known to be contagious.

4. **Phlegmonous Erysipelas.**—An acute rapidly spreading inflammation of the subcutaneous areolar tissue, secondarily affecting the skin. It is accompanied by very abundant exudation, and the gangrene that complicates it seems to be due chiefly to the tension caused by this. So far as is known it is not accompanied by any specific infection of the system, and its contagiousness is doubtful. It is associated with the presence of micrococci.

II. **General Infective Processes.**

1. **Cutaneous Erysipelas.**—An acute infective disease characterized by a superficial inflammation spreading in the skin from the wound, and by a general febrile disturbance of a specific character. It is supposed that the poison infects the whole system as well as the local seat of inflammation. It is associated with the presence of micrococci in the affected skin, and, according to some observers, also in the blood.

2. **Septic Infection.**—An acute general infective process, rapidly terminating fatally without the development of secondary centres of inflammation. The poison infects the whole system and increases in it, the fatal result being apparently directly due to alteration in the blood consequent upon the development of the virus in it. The local affection may be insignificant. The disease is rare in man. In animals it is easily induced experimentally, and in them is always found to be associated with a definite organism in the blood, differing in different species. It is most intensely contagious. By many writers it is spoken of as *septicæmia*, its name being derived from the fact that in animals it is capable of being caused by injection of small doses of putrid matter under the skin. The term *septic infection* is here used to distinguish it from *septic poisoning* caused by the chemical products of putrefaction, which by many writers is also spoken of as septicæmia.

3. **Pyæmia.**—A general infective process, almost invariably starting from a wound which has reached the stage of suppuration, and hence its name. It is characterized by the formation of secondary centres of inflammation and suppuration disseminated throughout the body. It is associated with the presence of micrococci in the blood and in the secondary centres of inflammation. It is believed to be contagious. It presents several varieties, which will be described when treating of the disease.

In actual practice it will be found that the distinction between these various affections is not always clearly defined, and this has given rise to the view that some of them at least are merely modifications of one disease. This apparent confusion may, however, be equally well explained by the co-existence of more than one form in the same case. Thus a patient may suffer from phlegmonous erysipelas with sloughing of the subcutaneous areolar tissue, decomposition of the sloughs may follow and give rise to septic poisoning, and, finally, death may take place from pyæmia.

It is impossible here to discuss fully the evidence for and against the theory of the fungoid origin of these diseases. It is supported by the presence of microscopic organisms in the local area of inflammation and in the blood, which has been so frequently observed in man, and by the universal presence of such organisms in similar diseases artificially induced in animals; and also by the fact that in analogous diseases in animals and in erysipelas in man, the

organism to which the poison is supposed to be due has been cultivated in suitable media out of the body for many generations, and, finally, when inoculated on a fresh subject, has given rise to the original specific disease. There is abundant evidence also to show that in many of these diseases the poison is particulate and not in solution, and that it is destroyed by those agents, whether physical or chemical, which are inimical to the lower forms of vegetable life. The close analogy, moreover, between some of these processes and splenic fever, in which the bacillus anthracis is undoubtedly, directly or indirectly, the cause of the disease, tends to support this view. Lastly, to many pathologists the hypothesis of a living virus, a contagium vivum, explains more rationally than any other theory the increase of the poison in the living body by a process resembling fermentation, its durability, and its evident dependence on favourable conditions, not only in the wound or in the individual but in his surroundings, in the time of year, the character of the season or climate, and many other circumstances. Lastly those modes of preventing these diseases which are the outcome of the application of the hypothesis of a contagium vivum to surgical practice have so far been the most successful.

The chief arguments urged against it are the following. In the first place, in the human subject many observers have failed to detect the presence of organisms in these diseases. The constancy, however, with which they have been found has of late years been steadily increasing with the improved methods of observation introduced by Weigert, Koch, and others ; so much so that this objection is becoming of little weight. It has also been urged that many processes, dissimilar in every respect, are found to be associated with the presence of organisms apparently perfectly similar. Thus micrococci are found in a simple acute abscess, in diphtheria, in erysipelas and in pyæmia ; but with bodies of such extreme minuteness differences may readily exist which it is beyond our power to recognize. Cohn, while referring to this question, called attention to the apparent similarity of the sweet and bitter almond, which yet differ from each other so widely in their chemical properties. A much more important objection, which is pointed out by Koch himself, is that in many cases in the human subject the number of microscopic organisms found has been singularly small, so small in fact as to make it difficult to understand how they could be the cause of such grave disease. Lastly, it has been maintained that the microscopic organisms are merely an accidental accompaniment of the process and not the cause, or that at most they serve merely as carriers of the virus and are not the producers of it. It is difficult to refute this assertion with the means at present at our command. When, however, as in the case of erysipelas, the organism can be cultivated for twenty generations out of the body in an artificial medium, and finally, on being inoculated on another individual will produce a genuine attack of the disease, it seems difficult to regard it as other than an essential factor in the production of the specific inflammation.

It must be acknowledged therefore, that, although it is highly probable that all this group of diseases arise directly from the action of microscopic fungi, the evidence is not as yet sufficient to furnish demonstrative proof of its truth.

Supposing, however, that the fungoid theory of infective processes in wounds were proved beyond a doubt, it would in no way disprove the facts

previously known as to the influence of bad hygienic conditions in the development of these diseases. The experience of generations of Surgeons has taught us that, although inflammation and suppuration with febrile disturbance result from contact with the raw surfaces of wounds of such simple septic products as must form in all dead tissues or putrescible animal fluids exposed to the ordinary air of a dwelling-house, the graver infective processes are of extreme rarity in cases treated in pure air and in the isolation of a private house. On the other hand, it has been established incontestably that if the cubic capacity of a ward be taken, and the rate of ventilation through it determined, a Surgeon may with certainty foretell how many suppurating wounds it will require in the absence of antiseptic treatment to generate infective disease in it.

Thus, although in the prevention of these diseases the use of antiseptics must take the first place as attacking the evil at its source, a strict attention to the laws of hygiene, as regards cubic space, ventilation, and general cleanliness, is also necessary to exclude those accessory conditions that favour its development. By these means combined all this group of diseases can be prevented; their occurrence is the result in almost all cases of some definite error in the treatment of the wound, or some infringement of sanitary rules. They are not accidental; they are preventable and ought to be prevented. Should a case arise, our knowledge of the nature of the diseases shows clearly how they may be carried from one individual to another, and the means to be adopted to prevent their spread.

The whole subject of the relation of these diseases to general hygienic conditions has already been discussed (p. 8 *et seq.*), and need not be further considered here.*

WOUND-DIPHTHERIA.

This name has been applied by French and German writers to an unhealthy condition assumed by granulating wounds or sores, in which they become covered by an opaque, white, or yellowish-white membranous layer closely resembling the false membrane of diphtheria. By English Surgeons it has more commonly been described as a mild form of phagedænic ulceration. It arises invariably in connexion with decomposing discharges, and is not uncommon in wounds over which urine is flowing. The granulating sore which may have been in a healthy and healing condition up to the time of the attack, becomes dark in colour, and here and there small hæmorrhages may be noticed amongst the granulations. The healthy discharge of pus ceases, and is replaced by a very slight serous exudation. Then an opaque white patch appears and soon spreads over the surface. The surrounding skin becomes reddened and slightly swollen, the edges are raised and sharply cut, and the sore may slowly spread and deepen. The opaque white layer on the surface is difficult to remove, but if a small piece be peeled off and examined microscopically it will be found to be composed of the superficial layers of the granulation-cells which have perished and become finely granular, mixed with a coagulated exudation. Throughout the whole layer are abundant

* Those who wish more fully to study the pathology of these diseases, should read Koch on Traumatic Infective Diseases of Wounds, translated by W. W. Cheyne, for the new Sydenham Society. An excellent summary of the relation of septic bacteria to disease, by Victor Horsley, will be found in the Report of the Medical Officer of the Privy Council for 1882. The most complete work on Septicæmia and Pyæmia is that by Carl Gussenbauer. In this will be found a catalogue of the literature and a complete history of the subject.

micrococci, singly, in chains, and in colonies. There is usually some slight febrile disturbance, and the nearest lymphatic glands are swollen.

Causes.—This unhealthy process is always the consequence of local neglect of cleanliness and general imperfection of hygienic arrangements. It may affect several wounds in a ward, but its contagiousness is not very clearly marked, and it frequently occurs in isolated cases. It has no relation to diphtheria. It is true that a similar unhealthy condition has been observed in wounds when the patient has been attacked by genuine diphtheria ; but the constitutional condition is then entirely different. Diphtheritic inflammation in the throat does not lead to the progressive destruction of tissue observed in the so-called wound-diphtheria. It is much more nearly allied to hospital-gangrene ; in fact, the term wound-diphtheria is extended by many writers on the continent to that process, the affection here described being regarded as the mildest form of the same disease. It is well, however, to separate the process above described from genuine hospital-gangrene, on account of its less evident contagiousness and its comparatively harmless character. The relation of the micrococci found in the slough to the process is not certain, though it is very probable they are concerned in causing the unhealthy process.

Treatment.—This is very simple. It is necessary only to apply some strong antiseptic lotion, such as chloride of zinc (gr. 40 to ℥j), carbolic acid (1 in 20), or the surface may be rubbed over with solid nitrate of silver or sulphate of copper. When a wound assumes this condition the hygienic surroundings of the patient should be carefully investigated, and any faults of ventilation, cleanliness or drainage corrected. In the mildest cases dusting the surface with iodoform may be sufficient to arrest the unhealthy process.

HOSPITAL-GANGRENE.

This affection is known also by the names of contagious or pulpy gangrene, or sloughing phagedæna, and by some French and German writers the term wound-diphtheria is extended to it. It is characterized by a rapidly destructive and spreading infective inflammation, the affected wound becoming covered as the process extends by an adherent slough. It attacks open sores and wounds. It is rarely met with in its fullest extent, except in military practice ; the accumulation of a large number of wounded persons with foul suppurating sores under one roof, and the want of proper cleanliness and attention during an active campaign, disposing to it. It used formerly to desolate the civil hospitals ; but, owing to the use of antiseptics locally and to the general sanitary measures now adopted in these institutions, it has practically disappeared from them. The occurrence of this foul disease is of itself condemnatory of the sanitary arrangements of the hospital in which it is developed, and in the present state of our knowledge is inexcusable.

Local Signs.—When hospital gangrene invades a wound or open sore that has hitherto been perfectly healthy, the surface becomes covered with grey soft points of slough, which rapidly spread, until the whole of the surface of the wound is affected. At the same time the sore increases rapidly in superficial extent, and commonly in depth ; the surrounding integument becomes œdematous, swollen, and of a livid red colour ; the edges of the ulcer are everted, sharp-cut, and assume a circular outline ; and its surface is covered with a thick pulpy greyish-green tenacious mass, which is so firmly adherent

that it cannot be wiped off, being merely moved or swayed to and fro when an attempt is made to remove it. There is usually some dirty yellowish-green or brownish discharge, and occasionally some bleeding; the pain is of a severe burning, stinging, and lancinating character; and the fœtor from the surface is great. The ravages of this disease, when fully developed, are very extensive. The soft parts, such as the muscles, areolar tissue, and vessels, are transformed into a grey pulpy mass, and the bones are denuded and necrosed. The larger blood-vessels resist the progress of the disease longer than any other parts, but may at last be exposed, pulsating at the bottom of the deep and foul chasm. There is, however, little risk of hæmorrhage in the early stages: but, when the sloughs are separating, an artery may give way, and bleeding to a dangerous or fatal extent ensue. Hennen states that there is most danger of this about the eleventh day. When the sloughs are thrown off, in the form of reddish-brown or greyish-green, viscid, and pulpy masses, a very sensitive granulating surface is left, having a great tendency to bleed, and to be again invaded by the gangrenous process.

Blackadder has described an ulcerated form of this affection, in which a vesicle containing a bloody ichor forms, with a hot stinging pain; this breaks, leaving a circular ulcer of about the size of a split pea. The ulcer once formed, rapidly extends by sharp-cut edges into the surrounding integument.

On the two occasions in which I have had, in former years, the opportunity of witnessing outbreaks of this disease in University College Hospital, the surface of the wounds affected became rapidly covered with a yellowish-grey pultaceous slough. In some cases there was hæmorrhage, but most commonly a small quantity of fœtid discharge only was poured out; the edges of the sore became sharp-cut and defined, and the ulceration extended further in the skin by an eighth or a quarter of an inch than in the subjacent areolar tissue. In most instances the disease was confined to the skin and areolar tissue, exposing but not usually invading the muscles and bones, though in some cases these were affected. The ulcers were somewhat circular, and were surrounded by dusky inflamed areolæ of some width. When once the morbid process was stopped, they cleaned rapidly, throwing out large vascular granulations.

Constitutional Symptoms.—In the early stage there may be active febrile disturbance, with high temperature and quick pulse. But these soon subside into symptoms of prostration. In the majority of cases they follow the local invasion of the sore; Blackadder, Rollo, Delpech, and Wellbank have all found this to be the case, and in the instances at University College Hospital it certainly was so. Hennen and Thomson, on the other hand, state that the constitutional symptoms precede the local. In this I believe them to be certainly in error. They have confounded that state of ill health which occurs in the wounded who are confined in the foul and reeking atmosphere of an over-crowded military hospital, and which predisposes to the invasion of hospital gangrene, with the symptoms produced by the phagedæna itself.

Causes.—All wounds and sores are liable to be attacked in this way, but the disease most frequently affects those that are of recent origin: the more chronic affections, and those that are specific, very usually escape. The experience of many wars has led incontestably to the conclusion that hospital-gangrene will certainly be developed amongst the wounded if they are aggregated in too large numbers under one roof, however large may

be the building; whilst, amongst the wounded who are treated in the open, or in "hut-hospitals"—mere temporary sheds—it is all but unknown. In many German hospitals in which it was formerly of very frequent occurrence, it has been entirely excluded by adoption of antiseptic methods of treating wounds, all other conditions remaining unchanged. It is evident, therefore, that the disease is primarily due to two causes, the over-crowding of patients in a ward and the putrefaction of the discharges from their wounds. The air is thus contaminated by the products of respiration, the exhalations from the bodies and excreta and the effluvia from the decomposing animal matter, while the wounds themselves are rendered prone to suffer from the infection by the irritation of the septic discharges in which they are bathed. I believe that the disease may at any time be produced by overcrowding of patients with suppurating wounds in the same ward or room. The last outbreak that occurred at University College Hospital, more than twenty years ago, was evidently due to this cause. In one of my wards, which is intended to contain 15 or 16 patients only, owing to accidental and unavoidable circumstances, 21 patients were admitted, and slept for one night, many of them having suppurating wounds. The result was an outbreak of hospital-gangrene, which spread through the Institution, and was most serious and persistent. But though it commonly has its origin in this way, especially in the crowding of military hospitals after a hard-fought action, it is met with out of hospitals. Well-marked cases of this affection, some of a very severe character, have at times occurred amongst the out-patients of University College Hospital. In these cases, as in many others, it is probable that the disease was occasioned by the neglect of hygienic conditions, in the close and ill-ventilated houses of the poor, aided possibly by some atmospheric or epidemic influence; erysipelas and phlebitis being also very prevalent at the time. This had been observed at the time of the first occurrence of the disease at our Hospital, in 1841; and it is impossible not to recognize a similarity of cause in these different affections. Hospital-gangrene is a highly contagious disease, and when once it has broken out it will readily spread from patient to patient by contact with nurses' or Surgeons' fingers, instruments, dressings, and above all if the pernicious custom of using sponges in cleaning sores be adopted. It is impossible to be too careful in these respects. It may also be carried by organic particles in the air, and thus be said to be "infectious."

Pathological Anatomy.—The slough is composed of the tissues of the part infiltrated with inflammatory products, the fluids having undergone coagulation. The individual cells are not recognizable, the whole presenting a finely granular appearance. When stained and properly prepared, innumerable micrococci are seen amongst the granules; they are in colonies or chains, or single. The perishing tissues immediately beneath the slough are infiltrated with migrating cells, which press upon the vessels, some of which are obliterated, and others filled with clots. Micrococci are recognizable in this region also. The relation of the micrococci to the process has not yet been definitely ascertained. Koch succeeded in inducing in mice a gangrenous process closely resembling hospital-gangrene by the inoculation of a form of micrococcus which showed a regular mode of growth in chains. The infective process was purely local, death occurring without infection of the blood. The micrococci were originally obtained from putrid blood, but subsequent inoculations from one animal to another were constantly followed by the same

form of gangrenous inflammation, and the development of the same definite form of micrococcus.

Treatment.—The **preventive treatment** of hospital-gangrene may be deduced from a consideration of the causes that give rise to it. The experience of many German surgeons, and especially Nussbaum, of Munich, has shown, that by the introduction of the antiseptic treatment the disease has been banished from hospitals in which, owing to faulty hygiene, it formerly existed to a fearful extent. On the other hand, it had been practically banished from English hospitals by attention to ordinary cleanliness, and general hygienic rules as to cubic space per patient, ventilation, drainage, &c., long before the introduction of antiseptic surgery. Still, up to twenty years ago it did occasionally break out, from temporary overcrowding, or from the accidental presence of an unusual number of large suppurating wounds in a ward. Now it is unknown in any properly managed civil hospital. In military practice antiseptic treatment is often impossible, and overcrowding unavoidable. The disease may then be prevented almost to a certainty by treating the wounded under canvas, in "hut-hospitals," or in the open. Should it break out, the building in which it has developed itself should at once be abandoned or destroyed. The spread of this fell disease may be prevented by at once isolating the affected patient, treating him in the open, putting him as it were in quarantine, allowing no contact between his attendants and other patients. Should it have broken out in a civil hospital, the first point to attend to is to *prevent the extension of the disease* to patients who are not as yet affected. This may be done by separating those who have been seized with it from the healthy, by preventing overcrowding of the hospital, ventilating the wards, washing the floors with a solution of chloride of zinc, whitening the walls, and fumigating the apartment with chlorine gas.

Local Treatment.—The first step in the local treatment is, to clean away the slough till the living tissues are exposed, the patient being under the influence of an anæsthetic. This must be done by means of scissors and forceps, by scraping with a sharp spoon or spatula, and by forcibly rubbing the surface with a sponge or a piece of tow. The metal instruments used for this purpose must afterwards be disinfected by being held in the flame of a spirit lamp, or put in a bath of carbolic lotion (1 in 20) ; the sponge or tow must be *immediately* burnt. The raw surface must then be freely cauterized by the application of fuming nitric acid, chloride of zinc, or the actual cautery. I prefer nitric acid, if strong and freely applied, the surface and edges being well sponged with it, The actual cautery is, however, very useful in those cases in which the surface to be destroyed is very extensive, or if there be a tendency to hæmorrhage. Should it not reach the deeper portions of the sore, nitric acid may be freely sponged into them. It is important to bear in mind that these escharotic applications will be fruitlessly expended in charring the tenacious grey pulpy slough, unless this have been previously cleared away. After the application of the caustic, the parts may be dressed with carbolic oil, terebene and oil, or some moist antiseptic dressing. The German Surgeons, who until recently had unusual opportunities of studying this affection, mostly preferred chloride of zinc. König recommends the following treatment. The sloughs having been cleared away, the surrounding skin must be washed with carbolic acid lotion (1 in 20), or chloride of zinc (20 gr. to ℥j). Some dry chloride of zinc is then moistened with water till it dissolves into an oily liquid ; cotton-

wool soaked in this is laid on the raw surface, and pushed into any irregular hollows or cavities of the wound, and allowed to lie there for from five to twenty minutes, according to the severity of the case. It is then removed, and some efficient form of antiseptic dressing applied. The pain is usually severe, and a hypodermic injection of morphia should be given to relieve it. The slough formed by the chloride of zinc will separate in from three to ten days, leaving a healthy granulating surface beneath, which may be treated on ordinary principles. In military practice, in which alone it is probable that hospital-gangrene will be met with in the future, chloride of zinc is by far the most convenient caustic, as it is carried in the solid state, while fuming nitric acid is dangerous and difficult to transport.

Should *arterial hæmorrhage* occur, it may be arrested by the application of a ligature to the bleeding point; but if this do not hold, as will probably be the case from the softened state of the tissues, the actual cautery must be applied; or the limb must be removed if all other means fail.

In some cases, though the sloughing is checked at one part of the surface, it has a tendency to spread at another. When this is the case, it may be necessary to apply the caustic or cautery repeatedly. In other instances, the sloughing cannot be stopped, but opens large arteries, and destroys the greater part of the soft tissues of a limb; and then it may be a question whether amputation should be performed during the spread of the disease, or the patient left to die of hæmorrhage or exhaustion. Such a contingency is not of common occurrence; yet it may happen and the operation be successful, as appears from the following case, though there would necessarily be great danger of a recurrence of the disease in the stump. The wife of a butcher applied at the Hospital, with a slight wound of the forearm, inflicted by a foul hook. It was dressed in the ordinary way, but in the course of a few days she returned with extensive sloughing phagedæna of the part. She was immediately admitted, and the disease was arrested by the energetic employment of the local treatment above described; not, however, until after considerable destruction of the tissues on the inside of the forearm had taken place. She left the Hospital before the wound was completely cicatrized, and returned in a few days with a fresh attack of the disease, more extensive and severe than the first, which could not be permanently stopped, either by the actual cautery or by nitric acid. The radial artery was opened and required ligature, and the whole of the soft parts, from the wrist to the elbow, were totally disorganized, and the bones exposed. There was now very severe constitutional disturbance, and the case was evidently fast hastening to a fatal termination. In these circumstances I amputated the arm midway between the shoulder and elbow; and, notwithstanding that the local disease was progressing at the time of the operation, and the great constitutional disturbance that existed, the patient having a pulse of 160 to 170, at which it continued for more than a fortnight, she made a good recovery; to which the free administration of quinine and stimulants greatly contributed.

The **Constitutional Treatment** consists in as nourishing a diet as the patient will take, with a liberal supply of stimulants; and these may be increased by the addition of the brandy-and-egg mixture, or of ammonia, in proportion as depression comes on. From five to seven grains of the sulphate of quinine should be given every four or six hours, with a full dose of opium at bed-time, or more frequently if there be much pain and irritation.

SPREADING TRAUMATIC GANGRENE.

Spreading Traumatic Gangrene, or as it is often called, **Spreading Gangrene,** the *gangrène foudroyante* of Maisonneuve, is a most acute and fatal form of infective inflammation usually following contused or lacerated wounds, particularly when complicated with fractures, or when opening a joint.

The **Causes** of the disease are extremely uncertain. The cases occur sporadically, and there is no evidence of infection, nor when one case arises in a hospital ward does the disease tend to spread to other patients. It is met with at all ages. The only constant condition present is a wound, usually contused or lacerated, often accompanied by injuries to bones and joints, and always complicated by an accumulation of putrefying blood or serum pent up within it. It is especially liable to occur if a lacerated wound be injudiciously closed by suture without proper drainage or antiseptic precautions.

It is most common after contused or lacerated wounds of the foot with considerable subcutaneous extravasation; it also occasionally follows similar injuries of the hand.

Symptoms.—Spreading gangrene always sets in before suppuration is established, usually on the second or third day. At first the symptoms appear to be merely those of ordinary septic inflammation, the result of pent-up decomposing discharges. There is febrile disturbance of the septic type: there are pain and swelling in the wound, with a blush of redness extending for some distance on each side of it. The true nature of the affection, however, speedily becomes apparent.

The wounded limb at the seat of injury swells, becomes dusky-red, and the seat of a deep-seated, tensive, burning pain. The swelling, redness, and tension spread upwards, and are speedily followed by a dusky purplish tint, by a soft doughy feeling of the parts, and in the course of a few more hours by a deep blackish-purple discoloration, which spreads uniformly and with great rapidity through all the tissues affected. This is accompanied or immediately followed by emphysematous crackling, due to the presence of gases which are developed by the decomposition of the parts attacked by the gangrene. The changes which are of a putrefactive nature, first develop in the wound itself, and speedily extend from it to the surrounding parts. That portion of the limb which is below the gangrenous part becomes pale, cold, and œdematous. The portion which is above becomes rapidly infiltrated by serous exudation, which runs up the inner side of the limb to the axilla or groin, as the case may be. The part immediately above the limit of the tissues that are actually mortified is swollen by œdematous infiltration, tense, pitting slightly on pressure, and usually of a dusky brownish-red colour; and frequently beyond the edge of the advancing redness, there is a brownish discolouration, apparently due to pigment, formed by breaking up of the red corpuscles in the gangrenous tissues and diffused beyond the area of inflammation. The process has no tendency to limit itself; the œdema and peculiar discolouration extend higher along the inner side of the limb, where it always first reaches the trunk. Emphysematous crackling rapidly spreads along the same parts, and the gangrene here travels with great rapidity, hopelessly involving the tissues and entering into the areolar planes of the axilla or groin in a very few

hours. As the gangrene advances, the parts affected fall into a soft, pulpy, black mass.

On making an incision into the parts so affected, it will be found that the gangrenous inflammation is primarily seated in the areolar planes of the limb, and that the muscles are not affected in the first instance. It will be observed also that the disease extends through the areolar tissue, the skin falling secondarily into slough.

The constitutional symptoms early assume the character of acute septic poisoning, the patient sinking into a prostrate condition, and the temperature falling below normal. Unless relieved by treatment death almost invariably ensues in three or four days after the invasion of the disease, and always shortly after the gangrene has reached the trunk.

Rod-shaped organisms—bacteria—have been found in great abundance in the gangrenous tissues, and the fluids of the part in which the process is extending. These are most probably connected with the rapid formation of offensive gases in the dead tissues, but what part, if any, they take in causing the spreading inflammation is not determined. That there is no specific constitutional affection is shown by the amount of success that attends early amputation above the affected part.

Treatment.—In the treatment of spreading gangrene the Surgeon will be placed in a great difficulty, whichever way he act. If he trust to constitutional treatment, in the hope of a line of demarcation forming, he will certainly be disappointed, the gangrene rapidly spreading up to the trunk ; and if he amputate, he may probably lose his patient by the stump becoming affected. Yet amputation should, in my opinion, be performed at once. For, although this operation is necessarily very unfavourable when practised in these cases, yet it must be remembered that, if the Surgeon wait for the line of demarcation or trust to other means, such as incisions or general treatment, the patient will certainly die. The only chance of safety in these cases, then, lies in amputating early, and removing the limb high above the part affected ; thus, in spreading gangrene of the arm, at the shoulder-joint ; and of the leg, in the upper part of the thigh. In most cases it will be found that the infiltration precursory to the gangrenous mischief runs up one side of the limb—the inner or posterior—to a much greater extent than the other. In amputating under such circumstances, the Surgeon may often very advantageously so fashion his flaps as to exclude as much as possible of the affected part or side of the limb, forming them chiefly from that least affected. A principal source of danger and of death, after amputation in these cases, is recurrence of the morbid condition in the stump, more particularly in the lower extremity. Out of twelve cases in which I have seen or done amputation for this disease, this recurrence happened in seven instances. This tendency will be increased by the proximity of the line of amputation to the gangrenous limit. But, even under the most unfavourable circumstances, recovery will sometimes take place. Thus I have seen the flaps in amputation for spreading gangrene infiltrated with gelatinous-looking fluid, and yet recovery take place. In a man whose arm I amputated at the shoulder-joint for spreading gangrene of the limb, the infiltration had extended as high as the scapula : yet he made a very excellent recovery. In the lower extremity the liability to recurrence of the gangrene is, however, very much greater ; and there can be but very little prospect of saving the

patient if the thigh have once become reddened and infiltrated, even though the gangrene do not extend above the knee—invasion of the stump ensuing under such circumstances with almost absolute certainty.

Much of the success of the case will depend on the after-treatment. This must consist principally of antiseptic dressings to the stump, full doses of liquor opii, and the early and free administration of stimulants, more particularly brandy and wine ; and attention to these points will often bring the patient through, though usually not without much difficulty and great constitutional disturbance.

CHAPTER XXXII.

ERYSIPELAS.

The term erysipelas, or erysipelatous inflammation, is applied to a group of infective inflammatory processes affecting the skin, the subcutaneous areolar tissue, intermuscular or subfascial areolar tissue, mucous membranes and submucous tissue, serous membranes and lymphatic vessels, and possessing one feature in common, *the tendency to spread with great rapidity by continuity of tissue, or in other words, to assume a "diffuse" form.* The true pathology of the erysipelatous inflammation is not sufficiently well known to enable us to separate the members of the group distinctly one from another. They are all due to the action of a virus, which infects the part attacked, increases in quantity in it by a process analogous to fermentation, and diffuses itself by means of the lymph-spaces and lymphatic vessels exciting a characteristic form of inflammation as it spreads. The virus most commonly enters the body by means of a wound, causing a primary local inflammation followed by a general infection of the system, accompanied by a definite form of febrile disturbance; but in some forms of erysipelatous inflammation there is evidence tending to show that the constitutional affection is primary and the local inflammation secondary, and again in others there is no evidence of a specific constitutional affection at all. These differences will be more clearly pointed out when discussing the individual members of the erysipelatous group of inflammations. The virus is probably not the same in all forms of the affection. The process is always accompanied by the presence of micrococci in the affected tissues, and in some cases in the blood, and evidence is steadily accumulating in favour of the view that these organisms take some part in the causation of the unhealthy inflammation.

Erysipelatous inflammation may attack a wound of any size or of any age; but the statistics of University College Hospital show that it most commonly arises in suppurating wounds, about two-thirds of the cases arising after the tenth day, and very few before the fourth.

The invasion of erysipelas is characterized by general malaise and depression, chilliness, and occasionally actual rigors, gastro-intestinal disturbance, accompanied by nausea, and sometimes by violent vomiting and purging. Cases have been recorded in which the first symptoms have been convulsions of an epileptiform character. During the chilliness the temperature rises to 103° or 104° F.; but the rise does not show the fluctuations common in pyæmia. The constitutional disturbance, although usually at first sthenic, very speedily runs into an asthenic type, presenting in severe cases the usual typhoid symptoms—a quick feeble pulse, brown tongue, pungent hot skin, and muttering delirium. The disease is essentially an affection of debility. This view of the nature of the constitutional disturbance in erysipelas is of great importance in reference to the treatment of the disease, as it demonstrates the necessity of not lowering the patient's powers too much during the early period of the affection, when it often temporarily assumes a sthenic character.

Erysipelas is especially apt to become complicated with visceral inflammations; the membranes of the brain, the bronchi and the lungs, or the gastro-intestinal mucous surface, are commonly implicated in this way; and it is often through these complications that death results.

Causes.—The causes of erysipelas are: first, the *essential cause*, the virus or contagium; and secondly, the *predisposing causes*, which may be either *local* or *constitutional*—the latter being again divided into those that are *intrinsic* to the patient, including those constitutional or local conditions predisposing him to receive the virus, and those that are *extrinsic*, such as are the conditions of life to which he is habitually exposed or by which he is surrounded after the injury or operation to which he has been subjected. The extrinsic causes may predispose the patient to receive the virus by impairing his general health, or may encourage the development of the poison and its transmission from one individual to another.

The **Essential Cause.**—Erysipelas is undoubtedly *contagious*. The contagion of erysipelas, after having been repeatedly denied, can no longer be contested. Travers, Copland, Bright, Nunneley, and others, have adduced cases in proof of its contagious character; and instances have repeatedly fallen under my own observation, in which erysipelas, often unfortunately fatal, has been communicated to the servants, nurses, or relatives of patients affected by it. A remarkable proof of the contagious nature of erysipelas occurred in the winter of 1851, in one of my wards at University College Hospital. The Hospital had been free from any cases of the kind for a considerable time, when, on the 15th of January, at about noon, a man was admitted under my care with gangrenous erysipelas of the legs, and placed in Brundrett Ward. On my visit two hours after his admission, I ordered him to be removed to a separate room, and directed the chlorides to be freely used in the ward from which he had been taken. Notwitstanding these precautions, however, two days after this, a patient, from whom a necrosed portion of ilium had been removed a few weeks previously, and who was lying in the adjoining bed to that in which the patient with the erysipelas had been temporarily placed, was seized with erysipelas, of which he speedily died. The disease then spread to almost every case in the ward, and proved fatal to several patients who had recently been operated upon. In some instances patients were affected with the constitutional symptoms without any appearance of local inflammatory action, but characterized by the same gastro-intestinal irritation that marked the other cases.

The *contact of dead or putrescent animal matters* with recent wounds may occasion it. In this way the disease is not unfrequently originated in hospitals by dressers going direct from the dead-house, and especially from the examination of the bodies of those who have died of diffuse inflammation, to the bedside of patients, without taking sufficient care to wash their hands or change their clothes. For this reason also it is of great consequence that the same instruments be not used for practising operations on the dead, and performing them on the living body.

As before stated there is no evidence to show that the virus is the same in all forms of erysipelatous inflammation, in fact there is strong reason to believe that it is not. In the cutaneous form of erysipelas, it was shown by Lukomski some years ago that the lymph-spaces of the cutis at the spreading margin of the inflammation contained large numbers of micrococci.

Quite recently Fehleisen has succeeded in cultivating these organisms on gelatine. A small piece of the affected skin was removed and placed on the prepared gelatine; after a short time a white film, which the microscope showed to be composed of micrococci, spread over the surface of the gelatine. A small speck of this was then planted on another gelatine surface and again the film formed. This process was repeated many times, until it might reasonably be supposed that any chemical poison which might theoretically have been adhering to the original organisms taken from the skin, was perfectly eliminated. The fungi were then inoculated on rabbits, and gave rise to a spreading inflammation, exactly resembling cutaneous erysipelas. Afterwards similar inoculations were made on eight patients in cases of cancer, sarcoma, and lupus, with the view of exerting the reputed curative action of erysipelas on these affections. Seven out of the eight patients, after a period of incubation of from fifteen to sixty hours, were affected by genuine erysipelas, with all the characteristic local and constitutional symptoms. In the one case in which the inoculation failed, the patient had recently recovered from a spontaneous attack of the disease. At the Congress of German Surgeons in 1883, Fehleisen exhibited a patient in whom genuine cutaneous erysipelas had been produced by the inoculation of micrococci which were thirty generations removed from the original organisms obtained from the skin, the cultivation having been continued on gelatine from August 1882 to April 1883. It may be said, therefore, to be almost proved to demonstration that either directly or indirectly the micrococci are the cause of the specific inflammation. These observations explain also the infectious and inoculable nature of cutaneous erysipelas.

There are at present no observations showing the nature of the virus in other forms of erysipelatous inflammation; but analogy would lead us to infer that they also are due to the invasion of parasitic fungi.

Predisposing Causes.—Local.—The principal local cause of erysipelas is certainly *the presence of a wound* or *raw surface*. The statistics of University College Hospital show that erysipelatous inflammation may attack a wound at any time from its infliction to its healing. This is especially true of the cutaneous forms; other varieties of erysipelatous inflammation more commonly start from recent wounds. The presence of decomposing discharges in the wound is undoubtedly an important predisposing cause, and antiseptic treatment has done much to prevent it. When erysipelas is epidemic, it is well for the Surgeon not to perform any operation that can conveniently be postponed; and in no case should a patient on whom an operation has recently been performed be put in a neighbouring bed to a case of erysipelas, or even in the same ward. The size of the wound has little influence on the occurrence of erysipelas, which takes place as readily from a small as a large one. But although the mere size of a wound does not influence the liability to the occurrence of erysipelas in it, which will as readily follow a puncture as an amputation-wound, yet its character does. Thus, lacerated wounds are much more liable to be followed by erysipelas than clean-cut incisions. And the depth of the wound influences in an important manner the severity of the erysipelas, which is more intense in those injuries that penetrate the fasciæ, even though they be cut to a very limited extent, when the disease may spread widely and fatally through the deeper subaponeurotic and intermuscular planes of areolar tissue. It is

important in these cases not to confound a simple septic inflammation due to the presence of decomposing matter in an ill-drained wound, with genuine erysipelatous inflammation. Injuries about the head and hands are said to be more liable to be attacked by erysipelatous inflammation than those of other parts.

Constitutional Causes.—Some persons appear to be *naturally predisposed* to erysipelas to so great a degree, that the application of cold, or slight stomach-derangement, or a trivial superficial injury, may excite it. This predisposition is most generally acquired by habitual derangement of health, and is especially induced by any of the depressing causes of disease, such as over-fatigue, anxiety of mind, night-watching, and habitual disregard of hygienic-rules as to diet, exercise, air, &c. The habit of body, however, in which erysipelas is most frequently met with as a consequence of very trivial exciting causes, is that which is induced by the habitual use of stimulants to excess. It is more especially in that state of the system characterized by an admixture, as it were, of irritability and of debility, in which all inflammations tend to reach the stage of suppuration, or to assume a diffuse form that erysipelas is most readily induced. This state is met with amongst the labouring poor, as the result of the privation of the necessaries of life, conjoined with the habitual over-use of stimulants and exposure to the various depressing conditions of bad food, impure air, &c. Amongst the wealthier classes it occurs as a consequence of high living, want of exercise, and general indulgence in luxurious and enervating habits.

Some *diseased states of the blood*, consequent upon visceral disease, appear to predispose, in the highest degree, to the supervention of erysipelas. This is especially the case in diabetes, and in disease of the kidneys attended by albuminuria. As a consequence of renal disease, erysipelas often occurs from the most trivial causes; such as a scratch, the sting of an insect, or any of the minor operations in surgery, more especially about the lower part of the body. Not only is it readily induced in this way, but it will extend in an uncontrollable manner in these states of the system, and will often assume a gangrenous form, there being apparently an utter want of power in the tissues to resist the influence of the virus. Persons of a gross and plethoric habit, with a tendency to gout, are predisposed to the occurrence of erysipelas. The blood-degeneration that attends malignant disease peculiarly disposes to erysipelas, which accordingly more frequently takes place after operations on persons having such diseases than after the removal of simple tumours.

Persons whose *nervous systems* are habitually depressed, the semi-idiotic and idiotic for instance, are very prone to inflammations of an erysipelatous form. A person who has once suffered from erysipelas is said to be more liable to the disease. Fehleisen states that his inoculation experiments showed that after the attack there is a short period of immunity, lasting a few weeks or months.

2. **Extrinsic Causes.**—Amongst the circumstances that surround the patient and that tend to the protection of this disease, season of the year and atmospheric changes exercise a marked influence. Erysipelas is usually supposed to be more frequent in the spring and autumn, and the experience at University College Hospital, where records of such cases have been very accurately kept, tends to confirm this idea. Thus we find that during the years 1871–2–3–4, 151 cases of erysipelas were treated in the Hospital, in-

cluding those admittted for the disease and those affected by it while undergoing treatment for other affections. Of these, 34 occurred during the cold months of December, January, and February; 43 during March, April, and May; 22 during the hot months of June, July, and August; and 52 during September, October, and November. It is an interesting fact, that during these four years only one case arose during the month of July. It has frequently been asserted that erysipelas often breaks out on the setting in of cold easterly winds or on sudden atmospheric changes. Observations were made during one year (1872) at University College Hospital with the view of testing the truth of this assertion; but, as they were not continued after that year, the time over which they extend is not sufficient to exclude chance from the results. As far as they went they tended to show that mild damp weather, with westerly winds, is a more powerful predisposing cause of erysipelas and other hospital diseases than cold dry weather with easterly winds, which is exactly the reverse of the popularly received opinion. The subject is one of great interest, and is well worthy of further investigation. Erysipelas often becomes epidemic as the result of peculiar, but at present inexplicable, conditions of the atmosphere. Thus at University College Hospital the number of cases occurring during the four years before mentioned was as follows: in 1871, 29; in 1872, 29; in 1873, 26; in 1874, 67. And not only was it at University College Hospital that this excess of erysipelas was noticed, but every similar institution in London suffered in the same way. It will usually be found that, when erysipelas is very abundant among the in-patients of a hospital, similar cases present themselves for treatment in the out-patient department; and at the same time it is generally noticed that phlebitis of varicose veins, epidemic catarrh, acute tonsillitis, and other allied affections prevail. Epidemic erysipelas may vary in its type. Thus the epidemic of 1874 was chiefly of the cutaneous variety, and was accompanied by comparatively slight tendency to gangrene or sloughing; while that of 1872, in Edinburgh, was of a violent phlegmonous type, usually attacking the subcutaneous tissue and leading to extensive diffuse sloughing and suppuration.

The great predisposing cause of erysipelas is, however, to be sought for and will be found in a *want of attention to hygienic conditions.* It is one of the penalties inflicted by nature on those who neglect those prime requisites of health—temperance and cleanliness—or who are incapable of obtaining good food and pure air. Were the laws of hygiene attended to as they should be, erysipelas and the allied diffuse inflammations would rarely be met with in surgical practice. *Overcrowding* of hospitals, and *want of proper ventilation* in wards or rooms, are fertile sources of erysipelas, and of the allied processes.

Erysipelas, however, cannot be as certainly generated in this way as some other unhealthy processes in wounds, such as hospital gangrene, or pyæmia. This has frequently been observed in military practice. Thus, after the battle of Sedan, although the wounded were in some hospitals almost decimated by pyæmia, erysipelas was very rarely met with. In the American War it is stated to have occurred in 0.4 per cent. of the wounded. It generally occurred in badly ventilated hospitals, and spread rapidly from one patient to another. It was less frequent in cases treated in tents, but occasionally it made its appearance under the most favourable hygienic conditions. These facts tend to confirm the view that genuine erysipelas is due to a specific virus which is not universally present. In old hospital buildings in which the disease has

frequently occurred the poison may be constantly present, waiting only for favourable conditions to manifest itself.

The different forms of erysipelatous inflammation are most conveniently described as they affect different tissues and organs. With this view, we may divide them primarily into External and Internal Erysipelas.

External Erysipelas is that variety of disease which affects the skin and subcutaneous areolar tissue. This form has been described with an absurd degree of minuteness, so far as the transitory and accidental characters of its duration, shape, and appearance are concerned, by many of the writers on Diseases of the Skin; who, in their anxiety to record minute and often accidental shades of difference in appearance, have entirely lost sight of the true nature of the disease. The division adopted by Lawrence into the **Simple**, the **Œdematous**, and the **Phlegmonous** forms, is a practical arrangement that is commonly adopted by Surgeons. I prefer, however, and shall adopt, the division made by Nunneley in his very excellent work on Erysipelas, as founded on the true pathology of the affection. He arranges external erysipelas under three varieties: 1. **Cutaneous**; 2. **Cellulo-cutaneous**; and 3. **Cellular**.

The statistics of University College Hospital give the following results. showing the relative frequency of these affections. During a period of ten years 196 cases were admitted under the care of the Surgeons or arose in the surgical wards. Of these 148 were cutaneous, 24 cellulo-cutaneous, or phlegmonous, and 24 cellular or cellulitis. To these may be added 36 cases of so-called idiopathic cutaneous erysipelas admitted under the care of the Physicians, making a total of 184 cases of the cutaneous form out of 232, or nearly 80 per cent.

1. Cutaneous Erysipelas is the slightest form of the disease, implicating merely the skin; it comprises many of the species of *erythema* of different writers, and corresponds to the **simple erysipelas** of Lawrence. To describe it merely as a *cutaneous* disease, a dermatitis, as has often been done, is, however, not only highly incorrect, but unphilosophical, and evinces a very limited acquaintance with its true nature.

The constitutional disturbance forms as essential a part of the disease as it does in scarlet fever or measles. In fact a constitutional fever may occur of precisely the same type as that which we observe to precede and to accompany the local inflammation, without any such complication. This I had special occasion to observe in a very fatal outbreak of erysipelas that took place in one of my wards some years ago. On that occasion, all the cases in which the cutaneous form of erysipelas appeared were marked by severe constitutional disturbance, attended by much gastro-intestinal irritation. But precisely the same type of general febrile symptoms, and the same irritation of the stomach and bowels, occurred in patients in the same ward in whom no local or surface manifestation of the disease took place.

Symptoms.—The invasion of cutaneous erysipelas is marked by alternate chills and flushes, but seldom by a distinct rigor. These are followed by headache, nausea, a quick pulse, a coated tongue, and hot skin; in from twenty-four to forty-eight hours the rash appears, though sometimes it comes out simultaneously with the constitutional disturbance. If there be a wound, its surface becomes dry, and the margins become slightly swollen, and the characteristic rash spreads away from them into the surrounding skin. The

disease may occur idiopathically also; that is to say, it may apparently start in the unbroken skin. Trousseau, and others, have asserted that even in these cases it always starts from some slight abrasion which has been overlooked. When arising in this way it commences most commonly at the junction of mucous membrane and skin, as at the angle of the mouth, the ala of the nose, the corner of the eye, the meatus of the ear, or the margin of the anus. In rare cases it may arise spontaneously on the limbs. I have seen it commence in the unbroken skin over an abscess. This so-called idiopathic erysipelas is the same disease as that in which the rash starts from a wound, although this has been doubted. During an outbreak of erysipelas in a surgical ward the two forms may arise in different cases as the result of the same infection.

The *rash* is of a uniform but vivid rosy-red hue, sometimes becoming dusky, and always disappearing on pressure; when advancing, it is characterized by a sharply-defined border slightly raised above the healthy skin, but when subsiding it fades away into the colour of the healthy skin. It is accompanied by some slight œdematous swelling, frequently recognizable only by the permanent impression left by the finger-nail pressed on the skin, but which is often considerable where the areolar tissue is loose, as in the eyelids and scrotum; and there is usually a sense of stiffness with a burning sensation in the part, and not unfrequently greatly increased sensibility. Vesicles or bullæ often form, containing a clear serum, which speedily becomes turbid, and dries into fine branny desquamation. The redness may spread rapidly along the limb or trunk, or, if the face be affected, may travel quickly from one side to the other, causing such swelling of the eyelids as to close them, and giving rise to swelling and much tensive pain in the ears. The disease is invariably accompanied by enlargement and tenderness of the lymphatic glands. In some cases this may even precede the rash. Sometimes the cutaneous eruption disappears in one part of the body and reappears in another. This, which is the *erratic* erysipelas, is often a dangerous form of the affection, occurring in advanced stages of pyæmia, and indicating the approach of death. In the idiopathic varieties of erysipelas, Arnott states that the fauces are always involved.

The inflammation in cutaneous erysipelas has no tendency to terminate in suppuration. In some parts in which the areolar tissue is very loose, especially in the eyelids, suppuration occasionally takes place. It then seems to be the result rather of the tension caused by the effusion than of the irritation of the specific virus.

When the inflammation is passing off the pain abates, the colour fades, the swelling subsides, and the cuticle, that has been detached by the serous transudation, flakes off in thin layers, and the skin returns to its normal state. In other cases, œdema of the part continues, with some irritability and redness of the skin and peeling of the cuticle; and in some rare cases the simple erysipelas seems to take on a gangrenous or sloughing character, especially about the umbilicus and genitals of young children.

The **Constitutional Symptoms**—The fever of cutaneous erysipelas continues as long as the rash is spreading. The temperature seldom rises above 106° F., more commonly it keeps below 104° F. There are no marked variations beyond the ordinary morning fall and evening rise met with in all febrile affections. The pulse may at first be full and strong, but it soon falls in force and becomes more frequent. There is frequently some delirium, which in the early stages may be violent, but later on becomes feeble and muttering.

Delirium is especially marked in erysipelas of the head, and was formerly supposed to be due to affection of the membranes of the brain. It has been shown, however, by *post-mortem* examination of fatal cases, that meningitis is very rare except in cases of erysipelas attacking a compound fracture of the skull, or spreading into the fat of the orbit. The delirium is usually due to the blood-condition, and is always a grave sign. The tongue is at first much coated, and soon becomes dry and brown ; there are also in most cases a good deal of derangement of the digestive organs, with tenderness about the epigastrium, and complete loss of appetite ; the evacuations are dark and offensive, and not unfrequently there is diarrhœa.

Cutaneous erysipelas is a most depressing disease, the patient even after a comparatively slight attack being frequently much reduced in strength, anæmic, and emaciated.

The duration of an attack of cutaneous erysipelas is very uncertain, it may last from three days to three weeks, and relapses are very common by which it may be prolonged to a month or more.

Pathological Anatomy.—After death the red tint fades, leaving the skin

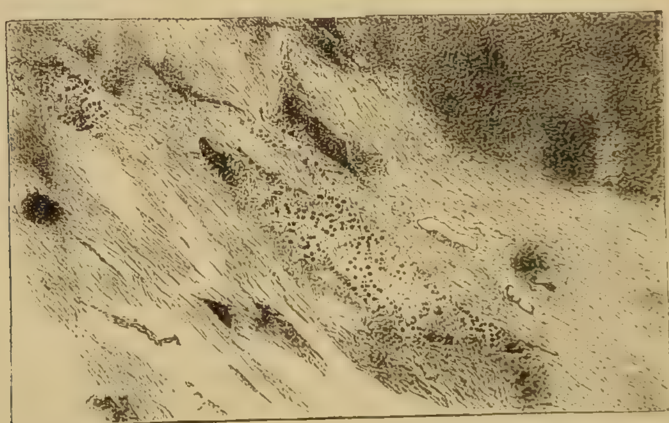


Fig. 354.—Micrococci in the lymph-spaces of the skin from a case of cutaneous erysipelas. The dark patch in the upper right hand corner is the deeper layer of the epidermis. (From a photograph by Koch.)

of a yellowish tint; if it be cut into, it is found to contain an excess of serous fluid. If the spreading margin be examined microscopically, numerous migrating leucocytes are found in the spaces of the fibrous tissue, especially around the vessels, and the lymphatic vessels also are blocked by similar cells. Lukomsky and V. Recklinghausen first pointed out that the lymphatic vessels and spaces in the spreading margin contain numerous micrococci, in some cases so closely packed as to form an opaque granular mass (Fig. 354). These are not present when the rash is receding, nor in the parts over which it has passed. These observations have been fully confirmed by subsequent observers. The relation of these organisms to the process has been already described (p. 898).

According to Koch, the micrococci are not found in the blood-vessels or blood. Hiller states that if the blood be examined numerous white corpuscles in a state of degeneration are found, having become converted into masses of highly refracting granules. Busk has described the occurrence of plugs of such corpuscles in the capillaries of the lung, and Bastian has observed a

similar condition in the brain. The internal organs present nothing that is characteristic. As in all diseases accompanied by high fever and general blood-poisoning, the epithelium of the kidneys and liver is found in a state of cloudy swelling, and the spleen is in some cases enlarged. The lungs are usually congested. Sometimes marked post-mortem staining of the blood-vessels and organs is found very soon after death, and occasionally small petechiæ are scattered beneath the serous membranes.

Diagnosis.—The diagnosis of the cutaneous erysipelas is generally easily made. From the *exanthemata*, it is distinguished by the character of the eruption; the way in which it spreads from a single spot, usually a wound or raw surface, and especially by the characteristic sharply defined margin. It is most commonly confounded with the red blush surrounding a wound in which septic matter is pent up; in this, however, the margin of the redness is not sharply defined; the enlargement of the lymphatic glands and the definite invasion are usually absent. From *inflammation of the veins or of the lymphatics*, the diagnosis is not always easy, more especially as the two conditions frequently co-exist. If a vein is inflamed, the general absence of cutaneous redness, the existence of a hard round cord, and the tenderness along the course of the vessel, are sufficient to establish the diagnosis. In inflammation of the lymphatic vessels the redness is not uniform, but consists of a number of small and separate red streaks, running in the direction of the lymphatics, and affecting the glands towards which they course. These two affections—erysipelas of the skin and inflammation of the lymphatics—are so frequently conjoined that a differential diagnosis is not of much importance.

Prognosis.—The prognosis in uncomplicated cutaneous erysipelas is by no means grave. Of 36 cases of idiopathic erysipelas admitted under the care of the physicians in University College Hospital during a period of ten years only two died, and one of them was suffering from chronic Bright's disease. When traumatic the disease is far more dangerous. Of 148 cases admitted under the Surgeons or breaking out in the surgical wards during a similar period 35 died. In only five is no special complication mentioned in the report, and one of those was an infant. Two died from pneumonia, seven of pyæmia which attacked the patient after the erysipelas had subsided, two of meningitis from injury to the head, two suffered from Bright's disease, two from severe constitutional syphilis, one from general albuminoid degeneration, two from advanced cancer of the breast, one from cancer of the liver, one from heart disease, two from suppuration of the kidney secondary to cystitis; one had a large cavity in the lung; one was an habitual drunkard, one was in very bad health, and one was dying at the time of invasion; one died from bed-sores, one from secondary hæmorrhage, one from an abscess, and one from thrombosis of the veins of the leg and sloughing of the skin after the specific disease had subsided. These statistics show that cutaneous erysipelas rarely proves fatal unless it attacks an individual previously suffering from grave constitutional disease, but that by exhausting the strength it may leave the patient liable to fall a victim to other complications of wounds such as pyæmia. Disease of the kidneys is always a most serious complication. High fever, violent delirium, profuse diarrhœa, and early prostration are grave signs during the progress of the case. Traumatic erysipelas is more dangerous than idiopathic, as other unhealthy processes are apt to follow in the wound; on the other hand, sores which have been making

no progress for a long time often heal rapidly after an attack of cutaneous erysipelas. The disease is most dangerous in the extremes of life.

TREATMENT.—**Preventive Measures.**—The occurrence of erysipelas is best guarded against by attention to hygienic measures, more particularly proper ventilation with pure air, and the avoidance of overcrowding of patients. In hospitals, the frequency of its occurrence may most materially be lessened by careful regulation of the hygienic conditions that surround the patient. With every care, however, erysipelas can never be completely eradicated from surgical wards, as it is often epidemic, brought into the hospital from without, and in many cases the conditions that lead to its development have influenced the patients so deeply before their admission into hospital, that no subsequent attention can prevent its occurrence afterwards. It often happens that erysipelas is unusually frequent in certain wards and even in certain beds. Its persistence in these respects will be found to be owing to some local cause, such as the emanations from a drain or dust-bin, on the removal of which the disease will cease. Scrupulous attention to cleanliness also on the part of nurses and dressers should be enforced, and the latter should not be allowed to go straight from the dead-house to the ward without previously washing their hands in some disinfectant or antiseptic solution. When erysipelas has already occurred, its further spread may be prevented by isolating the affected patients, and at once taking active measures to purify the ward from which they have been removed.

The *Curative Treatment* of cutaneous erysipelas must always be conducted with reference to the depressing character of the disease. The apparent intensity of the local inflammation observed in some cases, must not lead the Surgeon into the fatal error of employing any so-called antiphlogistic treatment. The treatment required is essentially of a tonic and stimulating character. The principal medicinal remedies consist of bark, quinine, iron, and ammonia. If there be much thirst, these remedies may be given in an effervescent form. But in any case they should be administered in frequent doses. If medicines are not well borne, the stomach rejecting them, I have seen the best possible results follow the free administration of the brandy-and-egg mixture, to which I am in the habit of trusting in the majority of these cases. During the progress of the disease, simple purgatives must be given from time to time. Tincture of the perchloride of iron, originally recommended by Hamilton Bell in small and repeated doses, is now often given in large doses, forty minims every four hours, by Russell Reynolds and others. It is supposed to exert a specific influence on the disease, and is certainly useful.

The *Local Treatment* is of equal importance with the constitutional. Innumerable modes of treatment have been recommended by different Surgeons, but all are agreed that the first essential is to keep the inflamed part warm. Cold lotions should never under any circumstances be employed; they lessen the vitality of the part, and may thus cause local sloughing. In slight cases the part should be covered with flour or starch powder dusted over it, and wrapped in cotton wool. In the more severe forms, warm applications assiduously continued, especially poppy and chamomile fomentations applied by means of flannels or spongio-piline, afford the greatest possible relief. The surface may at the same time be covered with a paint composed of equal parts of glycerine and extract of belladonna. Astringent applications to the inflamed surface, such as a strong solution of the nitrate of silver, are recommended by

some Surgeons. I saw them rather extensively employed in former years, but not with any very marked success. At University College Hospital the treatment recommended by Valette of Lyons has been lately tried in several cases with very good results. A 30 per cent. solution of perchloride of iron is prepared (roughly ℥j of solid perchloride to ℥iv of water) ; forty minims of this solution may be given internally with a little syrup or glycerine and water every two or three hours, and externally the pure solution is applied to the inflamed area. Valette insists that this must be done thoroughly, the solution must not merely be painted on, it must be rubbed in with a piece of lint or cotton wool. If necessary the grease must be removed from the surface of the skin by washing with soap and warm water before the lotion is applied. The application is repeated twice a day as long as it is necessary. A boundary line of nitrate of silver is occasionally drawn around the inflamed part, with a view of checking the extension of the disease. I have often done this, and seen it done by others, but never apparently with any benefit ; and have now discontinued the practice as an useless source of irritation.

The local abstraction of blood and of serum from the inflamed part, by the plan introduced by Sir R. Dobson, of rapidly making with the point of a lancet a large number of small punctures, from a quarter to half an inch deep, is of much value when the tension and swelling are extreme ; a hot fomentation cloth should be laid over the punctures so as to encourage bleeding, and the escape of serum. If the disease have attacked one of the limbs, the application of a bandage is occasionally necessary after the disappearance of the erysipelas, in order to remove the œdema that remains, and to support the softened and weakened tissues.

2. Cellulo-Cutaneous or Phlegmonous Erysipelas differs from simple cutaneous in so many respects, that by many authors it is regarded as an entirely distinct affection, dependent on a different virus and different predisposing causes. It was described by Dupuytren under the name of "diffuse phlegmon." The nature of the virus is not known, and there is no evidence that it is inoculable, though analogy would lead us to believe that it is so. It does not spread from patient to patient if a case be admitted into a general ward, nevertheless the patient should be isolated, as our knowledge of the nature of the disease is not sufficient to justify us in abandoning such precautions. It has been said to occur occasionally in an epidemic form. It rarely occurs in its worst form, except in persons who have been addicted to excessive drinking, or who are suffering from chronic disease of the kidneys. Locally, it differs from cutaneous erysipelas in the intensity of the inflammation, which is such that it invariably terminates, if left to itself, in diffuse suppuration and sloughing. In depth it always extends to the subcutaneous areolar tissue, and, though generally bounded by the underlying fasciæ, it not unfrequently implicates them if they have been opened up, and extends to the intermuscular areolar planes, the sheaths of the tendons, and other deep structures. There is no defined margin to the superficial redness, and the lymphatic glands are frequently unaffected.

Symptoms.—The inflammation may start from a wound or abrasion at an early period after its infliction, but frequently no such cause can be recognized. It is ushered in by the ordinary symptoms of inflammatory fever, accompanied or followed by the signs of severe inflammation in the part affected. The redness is uniform, of a deep scarlet hue, and pretty distinctly bounded ; the pain

is from the first pungent and burning, though it may soon assume a throbbing character; the swelling, at first soft, diffused, and pitting distinctly, soon increases, and becomes tense and brawny, the skin being evidently stretched to its full extent, and the part appearing to be perhaps twice its natural size. Large vesications or blebs containing sero-purulent fluid, sometimes blood-stained, appear in many cases. This condition usually continues up to the sixth or eighth day after the invasion of the disease, during the whole of which time the constitutional symptoms have presented the ordinary type of sthenic inflammatory fever; about this time, however, a change commonly takes place, either for better or for worse. If, under the influence of proper treatment, and in a tolerably healthy constitution, the inflammation subside, resolution takes place, with a gradual abatement of all the symptoms. If, however, as usually happens, the disease runs on to more or less sloughing or suppuration of the part, no increase of the swelling, pain, or redness takes place, but on the contrary, some diminution of these signs may occur, and thus give rise to a deceptive appearance of amendment. The skin becomes darkly congested, and the part, instead of being tense and brawny, has a somewhat loose, soft, and boggy feel, communicating a semi-fluctuating, doughy sensation to the fingers. This change from a tense brawny state to a semi-pulpy condition indicates the formation of pus and slough beneath the integument, and occurs without any material alteration in the size, colour, or general appearance of the part; pus can be detected only by careful palpation. Hence the Surgeon must daily examine with his own fingers the state of the part, and neither trust to the reports of others, nor to the general appearance of the diseased structures, for a knowledge of the probable condition of the subjacent tissues. If an incision be now made into the affected part, the areolar tissue will be found loaded with an opalescent fluid distending its interstitial loculi, but not flowing from the wound; the retention of this fluid gives a gelatinous appearance to the sides of the incision, which rapidly degenerate into slough and pus. If the alteration in structure have advanced to a stage beyond this, the areolar tissue will be found to have been converted into dense masses of slough, bathed in thin and unhealthy ichorous pus; these sloughs have not inaptly been compared in appearance to masses of decomposed tow, of wet chamois leather, or to the membranes of an embryo a few months old. Whilst these changes are going on below the surface, the skin, at first congested, becomes somewhat paler, and assumes a marbled appearance, rapidly forming into black sloughs, and being undermined by large quantities of broken-up areolar tissue and of ill-conditioned pus, without any appearance of pointing, however extensive the subcutaneous mischief may be. These destructive changes expose muscles, fasciæ, and blood-vessels, and may induce necrosis of the bone, or suppuration of the joints. They occur most readily in those parts of the body that possess the lowest degree of vitality, and hence are more common in the legs than in the scalp. As soon as the skin gives way the sloughs undergo ordinary offensive putrefaction, and the products of this process cause local aggravation of the inflammation and the constitutional symptoms of septic poisoning. If the patient recover, there will be tedious cicatrization of the deep cavities that are left; or considerable œdema, often of a solid character—a kind of false hypertrophy of the part—which may continue for some considerable time. In other cases, there may be such extensive local destruction or gangrene of the soft tissues, with exposure and death of the bones or suppuration of the joints,

that amputation of the limb may be required to save the patient's life. No operation of this kind, however, should ever be practised for the effects of erysipelas, unless they be strictly localized, and without tendency to spread; nor until the fever has subsided completely, except such as is of a hectic character, and dependent on the septic influences of suppuration.

During the progress of these local changes, the *Constitutional Symptoms* have assumed corresponding modifications. At first of an active inflammatory character, the fever, when suppuration and sloughing have set in, often suddenly becomes asthenic. Although in some cases there is at first no diminution in the severity of the symptoms, the constitution gradually gives way after the patient has struggled for a few days against the exhausting influences of the disease, and death speedily supervenes. If the patient survive the stage of sloughing, pyæmia with metastatic abscesses, septicæmia or hectic, from profuse discharge may carry him off. If recovery eventually take place, it may be with a constitution impaired and shattered for years. This disease is most fatal in the old and infirm, in habitual drunkards, or in young children. The immediate danger is always greatest when the head is affected. The remote danger from the effects of suppuration of areolar tissue, necrosis of bones, and inflammation of the joints, is greatest when the lower extremities are the seat of the disease.

A variety of the cellulo-cutaneous erysipelas has been described as **Œdematous Erysipelas.** By this is meant not merely the effusion into the areolar tissue which occurs in all the varieties of the disease, but a peculiar form, specially marked by œdema of the areolar tissue, with less inflammation of the skin than usual. There is much swelling, which pits deeply on pressure, with but little pain or tension, and but moderate redness of the skin; the constitutional symptoms are less marked than in the other varieties of the disease; it is principally met with in old people, or in persons of a dropsical tendency, in whom it occurs especially about the legs, scrotum, or labia, sometimes giving rise to permanent and solid enlargement.

Diagnosis.—Phlegmonous erysipelas is easily recognized by the characteristic symptoms just described, when arising from some slight superficial injury or spontaneously; but if it should happen to complicate a deep wound or compound fracture, it is easily confounded with *simple septic inflammation* consequent upon pent up decomposing discharges or blood. In all probability a very large proportion of the cases formerly described under the name of erysipelas were in reality simple septic inflammations not of a specific character. The so-called phlegmonous erysipelas of the scalp following a wound is, for example, almost invariably the result of the burrowing of putrid discharges beneath the pericranial aponeurosis.

From *spreading gangrene* it is distinguished by its slower progress and the absence of fœtid gases in the sloughs before the skin gives way.

Prognosis.—The prognosis in phlegmonous erysipelas is always grave. Of twenty-four cases admitted into University College Hospital seven died. It may be dangerous to the part affected or to life. It is especially dangerous if it affect the head or parts in which the areolar tissue is abundant and lax, as the scrotum or orbit. Much also will depend upon the promptness with which efficient treatment is begun and the means adopted to prevent septic poisoning from putrefaction of the sloughs. The disease is most dangerous at either of the *extremes of life.* If the *constitution* be sound,

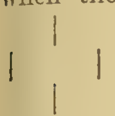
very extensive mischief may be recovered from; if, on the other hand, it be depressed or broken by want of the necessaries of life, by fatigue, over-exertion, or indulgence in stimulants, a very slight amount of disease may prove fatal. The most dangerous complication, and one which when it exists almost precludes the hope of recovery, is *chronic disease of the kidneys*, either in the form of the granular contracted, or of the large white kidney. I have never seen any patient labouring under these diseases, and attacked with phlegmonous erysipelas, escape with life; the sloughing and suppuration running on unchecked by any treatment that could be adopted.

Pathological Anatomy.—The most characteristic local feature is the distension of the spaces of the areolar tissue with an abundant coagulable exudation, and the subsequent suppuration and sloughing. The viscera present nothing special. There will be the signs of septicæmia (see septicæmia), or pyæmia (see pyæmia), should these affections have been the immediate cause of death.

Treatment.—In the early stage, our object is to prevent the inflammation from running into gangrene of the affected tissue. The fever being at this period commonly sthenic, the administration of purgatives, or effervescent salines may give relief. I have never seen a case in which blood-letting was required; and depressing remedies, such as salines, must be given with great caution. Medicinal tonics and dietetic stimulants require to be given early and late. As the disease advances, and symptoms of depression come on, a more stimulating plan of treatment must be adopted. In doing this, the pulse and the tongue must be our guides; as the one becomes feebler, and the other browner, so must ammonia, bark, and especially port wine, and the brandy-and-egg mixture, be administered. In the more advanced stages of the disease, when sloughing and suppuration are fully established, our sole object must be by nourishing diet, and the use of stimulants and tonics, more particularly the tincture of perchloride of iron, to bear the patient through the depression.

The *Local Treatment* of cellulo-cutaneous or phlegmonous erysipelas must be conducted on essentially the same plan as that of the cutaneous variety, though with more active means. The part affected must be kept at rest, must be elevated, if it be a limb, and have hot chamomile- and poppy-fomentations assiduously applied, cold being even more prejudicial here than in the form of disease last described; in this way, the swelling and tension may perhaps be removed, and sloughing of the areolar tissue prevented. In the majority of cases, however, other means will be required to effect this, and with this view none are more efficacious than incisions made into the part; by these an outlet is afforded for the blood and effused serum, which, by distending the areolar spaces of the part, produce strangulation of the tissues and consequent sloughing. This mode of practice, originally introduced by Mr. C. Hutchinson, is generally allowed to be the most effectual means we possess for the *prevention* of sloughing; hence the incisions should be made early, before there has been time for the tissues to lose their vitality. So soon, indeed, as they have become brawny, indurated, and tense, incisions properly made and placed will afford the greatest possible relief to the part and the patient, taking down the tension by the gaping, and the swelling by the exit they afford to the inflammatory exudation. Much difference of opinion has existed among Surgeons, as to the extent to which incisions should be practised in these cases; some recommending that one long cut should be made through the

inflamed structures; others contending, on the contrary, that a number of small incisions better answer the proposed end. The objections to the long incision are, that so considerable a wound not only inflicts a serious shock to the system, but that the loss of blood from it may be so great as to be fatal—cases having occurred in which life has been lost from this cause, or the hæmorrhage has been arrested only by the ligature of the main artery of the limb; and also that a single long incision does not relieve tension so effectually as a number of smaller ones. These preventive incisions consequently should be of limited extent, from two to three inches in length: at most they should not extend deeper than into the gelatinous-looking subcutaneous areolar tissue, unless it happen that the disease have extended beneath the fascia, when they may be carried through it also. South recommends that the



incisions should be so arranged in fours, as to enclose a diamond-shaped space, and states that in this way the greatest relief is given to the tension of the part. As it is not the object of the Surgeon to draw blood in these cases, any undue amount of hæmorrhage should be arrested by plugging the wound. Much blood may be saved by elevating the limb and applying a tourniquet before using the knife, but it is better not to employ Esmarch's bandage, for fear of driving the unhealthy inflammatory products into the circulation. In those cases in which the disease is not already complicated with an open wound and decomposing discharges, great advantage will be derived from the employment of antiseptic dressings, thus preventing decomposition of the effused inflammatory fluids which fill up the spaces of the areolar tissue exposed by the incisions. Before making the incisions, the limb should be well fomented for a quarter of an hour with cloths wetted with a hot solution of carbolic acid (1 to 40). The tourniquet is then applied, and the incisions made with antiseptic precautions. To arrest excessive bleeding, the wounds must be plugged with carbolic gauze. The treatment is then conducted according to the rules laid down when describing the antiseptic method. If the necessaries for this be not at hand, the part may be wrapped in hot oakum poultices, iodoform or salicylic wool or fomentation of boracic lint, or dressed with some other disinfectant application. After suppuration and sloughing have taken place, as indicated by a boggy feel of the parts, free incision should be made in order to let out pus and sloughs. After this, the skin will often be found to be greatly undermined, blue, and thin, with matter bagging in the more dependent parts; if so, egress must be made for it by free counter-openings, and drainage-tubes inserted as required. During the after-treatment, frequent dressing is necessary to prevent an accumulation of pus, and the sloughs must be removed as they form. Care should be taken not to destroy any of the vascular connections of the skin with subjacent parts; but, in order to get proper cicatrization, it will often be found necessary to lay open sinuses, or to divide bridges of unhealthy and blue integument stretching across chasms left by the removal of the gangrenous areolar tissue. If the loss of substance be great, the cicatrix that forms may be weak, imperfect, or so contracted as to occasion great deformity of the limb. In other cases, again, the diseased state of the bones and joints may be such as to call for ultimate amputation, either in consequence of the local deformity and annoyance, or in order to free the constitution from a source of hectic and of irritation. In all circumstances, the patient's health will usually continue

in a feeble and shattered state for a considerable time after recovery, requiring change of air, great attention to habits of life and a nourishing diet.

3. Cellular Erysipelas, or as it is more often termed **Diffuse Inflammation of the Cellular Tissue** or **Cellulitis,** has been particularly described by Duncan, Arnott, Lawrence, and Nunneley. It is an acute local infective process originating in the inoculation of a virus either in a wound or by a small puncture or scratch. Diffuse cellulitis may arise as a consequence of ordinary injuries, but it is especially apt to follow those in which there has been any inoculation of animal poisons, as from dissection wounds, the stings of insects, and the bites of venomous reptiles. Of the nature of the virus we know but little definitely, not enough either to assert or to deny that it may be in some cases identical with that which causes cutaneous erysipelas. The diversity of its origin, however, and the different course assumed by different cases would lead us to suppose that it is not always the same. The disease resembles erysipelas in the diffuse character of the inflammation, and it arises under circumstances similar to those in which erysipelas is observed to originate. In some cases the constitutional symptoms present nothing peculiar, being merely those of acute inflammatory fever ; in others, especially those arising from the inoculation of the poison of a dead body the symptoms may be those of acute septicæmia. The term cellular erysipelas or diffuse cellulitis must, therefore, be regarded as a clinical expression for an acute infective inflammation, spreading by the lymphatics and lymph-spaces of the areolar tissue, dependent upon a virus, the nature of which is uncertain, and possibly varies in different cases ; and not as implying a definite specific disease, such as simple cutaneous erysipelas undoubtedly is.

Local Signs.—The local signs will vary with the part affected. If it is the subcutaneous tissue of a limb, there are great swelling, tension and pain, and the part feels brawny in some parts, œdematous in others. The skin is slightly reddened in patches, has a mottled appearance, and may in extreme cases follow the same course as in phlegmonous erysipelas, running into blackish sloughs. This form in fact differs from phlegmonous erysipelas only in the affection of the skin being entirely secondary to that of the subcutaneous tissue. The extent to which the disease may spread varies greatly : when once it has set in, it frequently runs rapidly up the whole limb, extending also to the sides of the trunk.

In other cases, especially in the form that follows dissection-wounds, the inflammation at the seat of inoculation may be slight, the mischief being chiefly seated at a distance ; thus in a punctured wound of the finger, the diffuse inflammation may take place principally in the planes of areolar tissue in the axilla and sides of the chest. Diffuse cellulitis affects also the internal planes of areolar tissue. This may happen, for instance, in the fasciæ of the pelvis after lithotomy, or in the anterior mediastinum after operations at the root of the neck. In these cases there is deep-seated pain and tenderness, and the skin may be slightly reddened and œdematous. The superficial veins are often full and clearly indicated on the surface. Sloughing frequently occurs with remarkable rapidity, the areolar tissue being broken down into ill-conditioned pus and shreddy sloughs in the course of thirty-six or forty-eight hours, more especially when the disease has resulted from the inoculation of an animal poison.

The **constitutional symptoms** vary in different cases. In some they are

those of acute inflammatory fever ; in others the affection is accompanied by signs of the gravest blood-poisoning. In these latter there is probably a general infection of the system. After the sloughs become exposed to the air decomposition rapidly sets in, and the symptoms then assume the type of acute septic poisoning from the absorption of the chemical products of putrefaction.

Pathological Anatomy.—The state of the areolar tissue is the same as in phlegmonous erysipelas. Micrococci are found in the inflammatory exudations. Should the patient die, the viscera present the ordinary appearances of acute blood-poisoning (see Septicæmia).

Prognosis.—If the subcutaneous tissue of a limb only is affected many cases can be saved by proper treatment. Amongst twenty-four cases registered as cellulitis in the reports of University College Hospital there were six deaths. When the deeper planes of areolar tissue are affected, and when the process is very acute, death commonly supervenes early, often in two or three days ; in other instances life may be prolonged for some weeks, the patient ultimately dying from exhaustion or from some secondary complication, as pyæmia.

Diagnosis.—Superficial cellulitis closely resembles cellulo-cutaneous erysipelas, and in the later stages it may be indistinguishable when the skin becomes affected. In any case the diagnosis is of little importance as the treatment is the same. Deep-seated cellulitis is often very difficult to recognize ; the swelling, with some œdema and slight redness, the fulness of the superficial veins, and the deep-seated pain and tenderness, with the history of a cause likely to induce the disease, as a post-mortem wound, combined with the characteristic constitutional condition, will, however, usually enable the Surgeon to recognize the condition.

Treatment.—In the treatment of diffuse cellulitis it is usually necessary to administer stimulants early ; ammonia, wine, or brandy may be required from the very first. The Surgeon must judge of this by the constitutional condition of the patient, and more particularly by the state of his pulse and tongue. The *Local Treatment* is precisely of the same kind as that adopted in phlegmonous erysipelas, except that the incisions require to be made earlier and perhaps more freely ; in all other respects, there is no difference between the general management of the two forms of the disease.

SPECIAL FORMS OF EXTERNAL ERYSIPELATOUS INFLAMMATION.—**Erysipelas of Newly-born Infants, Erysipelas Neonatorum**, is occasionally met with, more particularly in lying-in hospitals, or in situations where the mother and child are exposed to depressing causes of disease. It usually appears a few days after the birth, at first about the abdomen and genitals, and soon spreads widely over the body, being characterized by a dusky redness, which rapidly runs into gangrene of the affected tissues. It starts in many cases from the raw surface left by the separation of the umbilical cord. It is extremely fatal, owing to the feeble vitality of the child, and presents but few points for treatment ; change of air and of nursing, with the administration of a few drops of spirits of ammonia or brandy from time to time, being all that can be done.

Cellulitis of the Orbit may occur primarily, or as the result of extension of the disease from the neighbouring structures. It is dangerous, and often fatal from meningitis. It commences with a violent deep-seated pain in the orbit ; the conjunctiva becomes injected and ecchymosed, the eyelids are

greatly swollen, red, and œdematous; the eyeball protrudes, and vision is impaired or altogether lost. Symptoms of cerebral inflammation may now set in, the patient becoming delirious and finally comatose.

The *Treatment* consists in fomentations, with early and free incisions into the orbit, made by pushing a lancet flat-wise between the eyeball and the orbital walls, through the inflamed conjunctiva, the eyelids having previously been everted. In this way inflammatory effusions and pus may be evacuated, and the eye saved. Destructive abscesses of the orbit, possibly of an erysipelatous origin, occasionally occur in the puerperal state, requiring, when practicable, the free evacuation of the pus, in the way just mentioned.

Diffuse Cellulitis of the Scalp following wound has been already described (pp. 715, 716).

Idiopathic Erysipelas of the Head is always of the simple cutaneous form, having no tendency to end in suppuration or gangrene. The only peculiarity it presents is the excessive œdema of the subcutaneous tissue that usually accompanies it, which completely obliterates the features. As the result of the tension caused by this, a little pus may occasionally form in the eyelids. Large blebs on the skin are very common. It is always accompanied by some redness and soreness of the throat. The inflammation as a rule starts from the junction of the mucous membrane and skin, as at the angle of the eye, spreading quickly to the bridge of the nose, at the orifice of the meatus auditorius externus, or the angle of the mouth. Its origin without a small abrasion or wound has been frequently denied. The course, symptoms, prognosis and treatment are those of simple cutaneous erysipelas (p. 914).

Diffuse Cellulitis of the Submaxillary Region was first accurately recognized by Ludwig, of Stuttgart, in 1836; hence the affection has sometimes received the name of Ludwig's Angina. It has been specially described also by Bickersteth, of Liverpool, and by Croly, of Dublin, and in an exhaustive paper by R. W. Parker (*Lancet*, Vol. II., 1879). Submaxillary cellulitis is an acute diffuse inflammation of the areolar tissue beneath the deep cervical fascia, attended by the ordinary severe constitutional symptoms of diffuse cellulitis, and terminating rapidly in suppuration, with sloughing of the affected tissues unless relieved by prompt and efficient treatment. The peculiar danger of the affection depends on the density of the cervical fascia, beneath which the inflammatory products are pent up at a high degree of tension, and the importance of the parts affected. The disease may commence without evident cause after exposure to cold, and is said occasionally to have appeared in an epidemic form; it may arise also from extension from the lymphatic glands in scarlet fever, or may follow wounds or other injuries. It may occur at any age; in adults, according to Furneaux Jordan, it most frequently occurs in those addicted to excessive drinking. It commences as a brawny inflammatory swelling at the fore-part of the neck, or near the angle of the jaw surrounding the submaxillary gland, or more rarely the parotid. It rapidly spreads towards the chin, extending to the opposite side, and afterwards down the neck over the larynx. The tongue is pushed upwards, and the hardened tissue can be felt in the floor of the mouth on each side of it; the movements of the jaw are interfered with, and deglutition becomes difficult. Sometimes there is great swelling of the tongue from pressure on the lingual veins. When gangrene of the areolar tissue sets in, the swelling becomes softer and boggy; the mucous membrane may give way, and a foul discharge may come from the

mouth. If unrelieved by treatment it is extremely fatal; death may occur from blood-poisoning or from suffocation, the disease spreading to the root of the epiglottis, and producing œdema glottidis.

The *Treatment* consists in making a free incision in the mesial line, from the chin to the os hyoides, through the infiltrated parts, from which, if it be made sufficiently early, a thin dark serum, but no pus, will be seen to exude. The incision must be carried to a depth of two inches or more towards the base of the tongue, keeping carefully to the middle line, until the whole of the brawny infiltration has been divided.

Erysipelas of the Scrotum, the "inflammatory œdema" so well described by Liston, is of frequent occurrence, as the result of wounds, ulcers, and other sources of irritation in this neighbourhood. The scrotum swells to a large size, being uniformly red, but with a semi-transparent glossy appearance, pitting readily on pressure, and feeling somewhat soft and doughy between the fingers: the integuments of the penis are also greatly swollen and œdematous, and sometimes the inflammation extends to the areolar tissue of the cord. The chief characteristic of this form of erysipelas is its tendency to run into slough without any previous brawny or tense condition of the parts; the dartos becoming so distended with the inflammatory exudation that the circulation through it is arrested. When an incision is made into it in this state it scarcely bleeds, and the sides of the wound present a yellowish-white gelatinous appearance.

The *Treatment* consists in making a free incision about four inches in length on each side of the septum, taking care not to go so deeply as to wound the testes; the part must then be supported on a pillow, and well fomented. If this incision be not made at once, a great part or even the whole of the scrotum may slough away, leaving the testes and cords bare; in these unpleasant circumstances, however, the parts will often with great rapidity become covered with new integument. The œdema of the penis usually subsides of itself, or after making a few punctures in it; should its integuments, however, threaten to slough, a free incision must be made into it, or the prepuce be slit up.

Erysipelas of the Pudenda is occasionally met with in ill-fed unhealthy children in whom cleanliness is neglected. The parts become of a dusky or livid red, swell considerably, and quickly run into gangrene, which spreads up the abdomen or down the nates. It may prove fatal by inducing peritonitis or exhaustion. In the *Treatment*, ammonia, bark, and chlorate of potash, with good nourishment, and a little wine, are the principal means, at the same time that the parts are bathed in a warm antiseptic solution and well fomented.

Diffuse Cellulitis of the Ischio-Rectal Fossa is not uncommon in old and feeble subjects, as the result of exposure to cold. The symptoms are those of cellulitis in general, a brawny hard swelling by the side of the rectum, with redness of the skin, and great pain and tenderness. The fat of the ischio-rectal fossa rapidly sloughs, and a foul, fetid abscess, the pus of which is mixed with shreds of gangrenous tissue, rapidly forms. The *Treatment* consists of free and early incisions. At a later stage it may be necessary to divide the sphincter before the cavity will heal.

Whitlow, or **Paronychia**, is an **Erysipelatous Inflammation of the Fingers.** It is a frequent affection in old and young people, either occurring spontaneously in cachectic constitutions, or arising from the irritation pro-

duced by scratches, punctures, or inoculation of the part with poisonous or putrescent matters. It is most common in the spring of the year, when, indeed, it sometimes appears to be almost epidemic.

That the inflammation of whitlow is essentially of the same character as that of cellulitis, and consequently may be classed as erysipelatous, in the broader sense of the word, appears to be proved by the following facts. 1. The causes, whether of season, infection, or local irritation, are the same in both affections. 2. The constitutional disturbance in whitlow is always very severe for a disease apparently so slight, and assumes the same character of speedy depression that we observe in erysipelas. 3. The inflammation of the affected finger is invariably diffused, and always tends to terminate in suppuration and sloughing. 4. So soon as the disease spreads beyond the affected finger, or to the back of the hand, it frequently assumes a distinctly erysipelatous appearance and character.

There are four degrees of whitlow. In the first, the inflammation commences in the cutis or immediately beneath it ; a drop of pus forms which, being unable to escape through the thick cuticle, burrows into the areolar tissue of the pulp of the finger, and thus gives rise to one of the succeeding degrees. It is important to recognize this form, as a very large proportion of whitlows commence in this way, and all further mischief may in such cases be prevented by shaving away the thickened cuticle, and thus giving exit to the pus without incision. In the second degree, the mischief commences deeply in the fibrous fat of the pulp of the finger. In the third degree, the sheath of the tendon is affected, either primarily or secondarily, by burrowing of pus into it, giving rise to the condition known as thecal abscess. In the fourth degree, the mischief either commences beneath the periosteum of the ungual phalanx or rapidly extends to it, causing necrosis of the bone. These degrees are occasionally distinct, but more commonly in clinical practice they merge into one another.

The most common form of whitlow is that in which the inflammation is confined to the dense tissue forming the pulp of the finger. It often arises from a very slight injury, as the prick of a pin, or a splinter in the finger, but not unfrequently without any recognizable cause. The part becomes extremely painful, hard, red, and swollen ; it then suppurates to a limited extent, with some sloughing of the areolar tissue. If an exit be now provided for the pus the inflammation ceases to extend, but in many cases, especially in the horny hands of the working classes, the pus is unable to find a way out through the dense cuticle, and consequently burrows more deeply into the pulp of the finger. In this way the ungual phalanx, which is imbedded in the pulp, may necrose, or the pus may find its way into the sheath of the tendon. There is usually some inflammation of the lymphatics of the arm ; and not unfrequently a good deal of febrile disturbance is present.

When, in the more severe cases of whitlow, the inflammation, which is of an excessively painful character, owing to the tension of the parts, extends to the sheath of the tendons, it then constitutes an affection that is fraught with danger to the utility of the finger or hand. The whole finger swells considerably, becomes red and tense, with much throbbing and shooting pain ; the inflammation rapidly extends to the back of the hand, which becomes puffy, red, and swollen. Although the palm be greatly swollen, it usually preserves its natural colour, or becomes dull white, owing to the greater thickness of its

cuticle. Pus rapidly forms in the finger, and may extend to the palm of the hand, finding its way into the common sheath of the flexor tendons, and spreading up the forearm under the annular ligament. Whitlow affecting the little finger or thumb is much more likely to cause suppuration in the common sheath of the flexor tendons than when it occurs in any of the other fingers. This is due to the fact that the synovial sheaths of the flexor tendons of the thumb and little finger generally communicate with the common sheath, while those of the three other fingers do not. There is usually no fluctuation to be felt in the finger, even though pus may have formed, but in other parts of the hand it may readily be detected in the usual way. In these cases there is always much sloughing conjoined with the suppuration; the areolar tissue of finger and hand, the tendons and their sheaths, and the palmar fascia being all more or less implicated. In some cases the end of the finger, as far as the first phalangeal joint or the middle of the second phalanx, falls into a state of gangrene and has to be separated. In many cases the joints of the fingers are destroyed, and the phalanges necrose; or, if this do not happen, the tissues of the part may be so matted together, as the result of sloughing and suppuration, that rigid and contracted fingers, or a stiff and comparatively useless hand, may be permanently left.

In the *Treatment*, the patient should be well purged and kept upon a moderate diet during the early stages. In all cases of whitlow affecting the pulp of the finger the part should be soaked in hot water for a short time, after which the thick cuticle should be carefully shaved down with a sharp knife. If a specially tender spot can be recognised it often happens that as the cuticle is removed at that part a drop of pus escapes, which gives immediate relief. By this plan of treatment incisions can be very frequently avoided and the mischief cut short.

In severe cases the two essentials in the treatment consist: First, in the arrest of the inflammation, and secondly, failing in that, in the prevention of necrosis of tissue, whether areolar, tendinous, or osseous, by strangulation from the extreme tension of the inflamed parts.

The first object is best accomplished by smearing the affected part thickly with belladonna and glycerine, covering it up in cotton-wool, and keeping the hand slung. In many cases this treatment will arrest the inflammation, limiting the disease to its first degree. Should the inflammation, however, extend, spreading with deep throbbing to the back of the hand and palm, or creeping up the course of the lymphatics of the arm to the axillary glands, no time should be lost in giving exit by means of free incisions to the engorged and tense tissues, and thus preventing the occurrence or limiting the spread of slough and pus. With this view, a free incision should be made in the palmar aspect of the finger, its length and depth proportionate to the extent of the inflammation. In opening a deep-seated palmar abscess, there is danger of wounding the branches of the median nerve, the superficial palmar arch, and the digital arteries. These structures may all be avoided, and the operation done safely, by making the incision toward the head of a metacarpal bone, upon the bone itself and parallel to its axis, so as to avoid the digital interspaces. The sheath of the flexor tendon should be spared if possible; but if it be affected it must be freely opened, or the tendon will certainly slough and the finger be permanently stiffened. This incision should be made from the proximal towards the distal end of the finger, so that if the patient involun-

tarily draw it back it may meet the knife. But these incisions if deep are horribly painful, and an anæsthetic should never be omitted. After incising the finger the limb should be well bathed and fomented several times in the day, the finger itself dressed with carbolized lint, covered with a piece of gutta-percha tissue, joined along the edges by a touch of chloroform. Poultices make the parts sodden, and are injurious by their decomposition. In cases of extensive implication of the hand the limb should be supported by a splint, and in all cases the dressings covered with cotton-wool. The dead and sodden cuticle should be cut away with scissors, as it frequently seriously interferes with the escape of the discharges and sloughs. After the opening has been made, and any slough which may have formed has come away, it not unfrequently happens that a large and fungoid granulating mass sprouts up; this will, however, gradually subside, as the swelling of the finger goes down and the inflammation abates. If the nail become loosened, it had better be removed, as it may otherwise keep up irritation; it must not, however, be torn off if adherent, but merely scraped and cut away so far as it is loose. When the whole of a finger is affected, the hand should be placed on a splint as soon as the inflammation has been somewhat subdued, lest contraction of the affected finger, which may eventually extend to the neighbouring ones, ensue. The finger should not be placed in a fully extended position, or it will be impossible after recovery to break down any adhesions that may form between the flexor tendons and their sheaths.

Should the lymphatics of the arm become implicated, belladonna and glycerine should be freely applied, the limb covered with cotton wool and supported in a sling.

When the joints are implicated, destruction of the cartilages commonly ensues; yet, by position, and rest on a splint, a tolerably useful though stiffened finger may be retained. When the bones are implicated, some operative procedure usually becomes eventually necessary. If the ungual phalanx alone be necrosed, it may be excised through an incision on the palmar side of the finger, the pulp and nail being left; in this way I have often preserved a finger that must otherwise have been removed. Amputation of the finger at the metacarpo-phalangeal articulation will usually be required when the second or proximal phalanges are involved; though here partial excision, by cutting and scraping away the diseased bone, may sometimes be usefully done. During the later stages of these affections, tonics, good diet, and stimulants will be required for the re-establishment of the health.

Senile Teno-Synovitis.—There is a form of acute suppurative inflammation of the fingers and hand sometimes extending to the wrist-joint, which occurs in old people of feeble constitutions. It usually arises from some trivial irritation or infection, and runs its course of disorganization with rapidity. It appears to be a disease of the hand due mainly to senile degeneration, in this respect resembling the gangrena senilis of the foot, but differing in its more acute character and suppurative tendency. The joints of the fingers, metacarpus and carpus, become disorganized and the bones necrose. This disease requires an active tonic and nutritive treatment. The affected parts should not be too much soddened by wet applications. Amputation, partial or complete, may at last be required.

INTERNAL ERYSIPELATOUS INFLAMMATIONS.

By **Internal Erysipelas** we mean those forms of diffuse inflammation which affect the Mucous or Serous Surfaces.

ERYSIPELAS OF MUCOUS SURFACES.—The mucous tract that is chiefly affected by this disease is that covering the fauces, the pharynx, or the larynx.

Erysipelas of the Fauces may occur in consequence of the disease spreading from the head and face to these parts; or it may commence as a primary affection, occurring perhaps at the same time that the rash appears on the cutaneous surface of some distant part of the body. When the fauces are erysipelatous, they present a bright crimson or scarlet colour, with some swelling and thickening of the soft palate and uvula; the patient also most commonly has some huskiness or complete loss of voice, and occasionally some croupy symptoms. The glands at the angle of the jaw are always swollen and tender. At the same time there is a good deal of febrile disturbance, with a pungent hot skin and quick pulse. This form of erysipelas is peculiarly contagious, and occurs not unfrequently in the attendants of those who are labouring under some of the other varieties of the disease; of this I have seen numerous instances. In many cases, also, it is epidemic, spreading through a house and affecting almost every inmate.

Treatment.—The best results are obtained by sponging the inflamed parts freely with a strong solution of the nitrate of silver; and, if there be much constitutional depression, by administering full doses of ammonia, with camphor or bark. Should the disease go on to sloughing (which not unfrequently happens), constituting one of the forms of "putrid sore throat," the mineral acids and bark, with chlorinated gargles, and the brandy-and-egg mixture for support, will be found most useful. In many cases, this disease continues limited to the palate and fauces; but in others it extends upwards or downwards. It may extend upwards through the nares, out of the nostrils, and thus spread over the face and head, or downwards, implicating the larynx.

Erysipelatous Laryngitis, as described by Ryland, Budd, and others, is extremely dangerous. The inflammation, commencing in the fauces, rapidly spreads to the mucous membrane and loose submucous areolar tissue external to and within the larynx, giving rise to extensive œdematous infiltration, which, by obstructing the rima glottidis, may readily suffocate the patient. In consequence of this special tendency to œdema, the disease has by many writers been termed "*œdematous laryngitis.*" After death, the submucous areolar tissue of the fauces, that about the base of the epiglottis, and especially that which enters into the arytæno-epiglottidean folds and that covering the posterior part of the larynx, will be found to be distended with serum or a sero-puriform fluid. This infiltration reaches to the rima of the glottis, and, extending into the interior of the larynx, gives rise to such swelling that its cavity is nearly obliterated. Great as the swelling may be, however, in all these parts, it never spreads below the true vocal chords. This fact, which is very important, is explained by the mucous membrane coming closely into contact with, and being adherent to, the fibrous tissue of which these structures are composed, without the intervention of any submucous areolar tissue. The progress of this œdematous inflammation of the mucous membrane and

loose submucous tissue in these situations, is often amazingly rapid, the swelling being sufficient to induce suffocation at the end of thirty-six or forty-eight hours, or even sooner. If the patient be not carried off in this way, there will be a great tendency to suppuration and sloughing of the affected tissues, leading perhaps eventually to death from septicæmia or pyæmia.

The *Symptoms* of this affection are strongly marked. The patient, after being attacked with erysipelas of the fauces, attended by some difficulty and pain in deglutition, and huskiness of the voice, is seized with more or less difficulty in breathing, coughs hoarsely and with a croupy sound, and complains of tenderness under the angles of the jaw and about the larynx. The difficulty in breathing increases, and may speedily threaten the life of the patient, giving rise to intense fits of dyspnœa, in one of which he will probably be suddenly carried off. The difficulty is greater in inspiration than in expiration, as the swollen parts above the opening of the larynx fall together like a valve in the former act, while they are easily separated by air coming from below in the latter. On examining the throat the fauces will not only be observed to be much and duskily reddened, but by depressing the tongue the epiglottis can be felt, and perhaps seen, to be rigid and erect. Examination with the laryngoscope readily shows the condition of the parts to be as above described. Enlarged lymphatic glands can usually be felt early in the case behind the angle of the lower jaw.

In the *Treatment*, local means are of the first importance. The tongue having been well depressed, the posterior part of the larynx, the epiglottis, and the arytæno-epiglottidean folds must be well scarified by means of a hernia-knife, with which this operation may be most readily and safely done. If no better instrument be at hand in case of emergency, a very useful amount of scarification may be done by the nail of the Surgeon's index-finger, notched with a knife to make it tear the mucous membrane more readily. The patient should then be directed to inhale the steam of hot water, and several leeches may be applied under each angle of the jaw, to be followed by large and hot poultices; at the same time, the bowels must be kept well opened, and the patient treated by antiphlogistic measures or otherwise, according to the constitutional condition. Most frequently, I have found antimonials of great service in the early stages, followed later by support and stimulants. A few hours after the engorged tissues have been unloaded by scarification, the fauces, pharynx, and upper part of the larynx should be well sponged out with a strong solution of the nitrate of silver (sixty grains to an ounce), which must be applied freely. If, notwithstanding the employment of these measures, the dyspnœa increase, the face becoming pale, livid, and bedewed with a clammy perspiration, it will be necessary to open the windpipe to save the patient from suffocation. In doing this I prefer laryngotomy, for reasons that will be mentioned when I come to speak of the Diseases of and Operations on the Air-passages. In order, however, that this operation may be successful, it must not be too long delayed, and should not be looked upon as a last resource: if it be done in time (and time in these cases is most precious, owing to the rapid progress of the disease), the patient's life may probably be saved; but if it be deferred too long, congestion of the lungs will come on, the blood will cease to be properly oxygenated, and the patient will sink from slow asphyxia, even though air be at last freely admitted. If the patient survive to the stage

of sloughing, general support, with gargles of chorate of potash, and bark, must be our chief reliance.

Erysipelas of the Serous Membranes was formerly supposed to be of common occurrence, all those cases of diffuse inflammation which are now regarded as of septic origin being at one time classed as erysipelatous. It is highly probable that some cases of diffuse meningitis and peritonitis following injuries of the head and abdomen are truly erysipelatous and dependent upon a specific virus; but in by far the greater proportion of these cases the inflammation is due to the diffusion of decomposing discharges over the surface of the serous membrane.

CHAPTER XXXIII.

SEPTICÆMIA AND PYÆMIA.

Definitions.—The terms septicæmia and pyæmia have been used with different significance by different authors, and before proceeding to discuss the affections to which they are applied, it is necessary briefly to define the sense in which they will be used here.

The term **Septicæmia** is applied to a constitutional disorder produced by the entrance into the blood-stream of a poison generated in a wound, the discharges of which are undergoing putrefaction or fermentative changes. The resulting process is not accompanied by the formation of secondary or metastatic centres of inflammation or suppuration. Experiments on animals have shown that two distinct forms of disease may arise from the entrance of putrid matter into the blood-stream. First, an acute general affection, not infective in character, resulting from the admixture of the chemical products of putrefaction with the blood; this poison does not increase in the system, and its effects are proportioned to the dose. Secondly, a true infective process, dependent on a specific virus, which multiplies in the organism like that of an acute specific fever, so that its effects are not proportional to the original dose. The former of these conditions has received the name of **septic poisoning,** or **septic intoxication,** the latter of **septic infection.** By some authors the infective form of septicæmia has been described under the name of pyæmia simplex.

Pyæmia is a general disease consequent upon the entrance into the blood-stream of a virus contained in the products of a local unhealthy inflammation. It is accompanied by the formation of secondary centres of suppuration disseminated throughout the body. The name pyæmia was originally derived from the theory that the disease was due to the entrance of pus into the blood-stream, and, although this theory is no longer regarded as true, the word has come to have so definite a clinical significance that it would be inconvenient to change it. Pyæmia almost invariably arises in connexion with wounds the discharges of which are in a putrid condition, and is consequently frequently complicated with septic poisoning. It may arise also from wounds or sores which have previously been attacked by cutaneous erysipelas, diffuse cellulitis, or hospital gangrene. It is evident, therefore, that in actual practice these various secondary diseases often become more or less confused together, giving rise to forms apparently intermediate between the different affections, which have led to much confusion with regard to them.

Experimental Investigations into the Nature of Septicæmia and Pyæmia.—The earliest experiments on this subject were made by Gaspard in the early part of this century and first published in 1822, since which time investigations have been almost continuously carried on up to the present time by Virchow, Panum, O. Weber, Billroth, Bergmann, Burdon Sanderson, Chauveau, Koch, Hueter, Klebs, and many others. The literature of the

subject is now so vast that it is impossible here to give more than the briefest possible summary of the results that have been obtained.

If a septic liquid, such as putrid blood or serum, or water in which animal tissues have been macerated, be carefully filtered and injected either into the subcutaneous tissue or directly into a vein of an animal, certain definite symptoms are produced.

If the dose injected be in sufficient quantity to prove fatal, the first symptom is a slight shudder, followed by some muscular twitchings and restlessness; but muscular power soon begins to fail and the animal falls on its side. In the meantime symptoms referable to the alimentary tract develop themselves; vomiting and profuse diarrhœa with tenesmus set in. The ejecta are at first feculent, but rapidly become serous and tinged with blood. Dyspnœa sets in, the power in the voluntary muscles is still further lost, and death ensues apparently from failure of the heart's action. The temperature rises at first from three to four degrees and then gradually subsides, rapidly falling at last to one or two degrees below the normal as the animal dies. The fatal effect is produced in from two to three hours, or even less, to twenty-four hours, or more, according to the dose. If the quantity injected be insufficient to cause death the animal quickly recovers its normal health, even though severe gastro-intestinal symptoms may have been induced. When smaller doses are used a febrile disturbance of limited duration is the only result.

If an animal killed in this way be examined after death, tolerably uniform appearances are met with; the blood is dark-coloured, and sometimes imperfectly coagulated, the inner coats of the vessels and the endocardium are darkly stained, and the serum is reddened by the colouring matter of the red corpuscles, which have become, to a certain extent, disintegrated in the blood even before the death of the animal. Small extravasations of blood (petechiæ) are found beneath the pericardium and pleura, and occasionally in other parts; the lungs are congested, the glandular viscera swollen, and the spleen enlarged, soft, and pulpy. The mucous membrane of the intestines is intensely injected, and its epithelium is found to have been separated.

Further experiments have shown that the blood in an animal thus killed is not infective, and contains no recognizable microscopic organisms. The process is, therefore, assumed to be one of simple poisoning by a chemical poison, and no more an infective process than if arsenic or any similar substance were injected into the blood-stream. From the time of Gaspard efforts have been made to ascertain the exact chemical nature of the toxic substance developed in animal fluids during putrefaction. This, however, has not as yet been accomplished. By adding strong boiling alcohol to a clear filtered solution of putrid meat-infusion a precipitate is obtained, which can be again dissolved in water, and the clear solution possesses the most intensely toxic properties, giving rise, if injected, to the characteristic symptom of septic poisoning. The poison is, therefore, soluble in water and precipitable by alcohol. Bergmann succeeded in further extracting a crystalline substance, to which he gave the name of "*sepsin*," but it has not by any means been conclusively proved that this is the sole poisonous principle in putrid fluids. The clear solution of the septic poison is perfectly free from microscopic organisms. The relation of microscopic organisms to the process of putrefaction has already been discussed (p. 164); and assuming the germ-theory of decomposition to be true, bacteria, although not themselves concerned directly in the production

of the symptoms of septic poisoning, are essential to the production of the poison. That they are not the actual poison was shown by Hiller, who collected a mass of the ordinary bacteria of putrefaction on a filter, washed them in distilled water, and then injected them into animals, and also into his own body without producing any evil effect. That the bacteria had not been injured by the distilled water was shown by other experiments in which their power of growing and causing putrefaction in organic solutions was demonstrated.

Those experiments may, therefore, be said to show that in the process of putrefaction a complex substance is formed which is soluble in water, and possesses intensely toxic properties, in small doses giving rise to severe febrile disturbance, in large doses causing a fatal illness accompanied by definite symptoms. The affection thus produced in its most intense form is spoken of as septicæmia, but to avoid confusion is better termed septic poisoning. The effect produced by a smaller dose forms, as has already been pointed out, one form of so-called traumatic fever.

The injection of putrid animal fluids into the subcutaneous tissue or blood-stream is not, however, in all cases followed merely by poisoning from the chemical products of putrefaction. Under certain conditions a true infective process ensues, as was first pointed out by Davaine. The best example of this process is perhaps furnished by the experiments of Robert Koch, in which putrid fluids, such as blood or meat infusion were injected into mice beneath the skin of the back. If the quantity used was sufficient, the animals died with all the symptoms of septic poisoning in four or five hours. When one drop only was injected about two-thirds of the mice recovered without any serious symptoms, but in the remaining third, after twenty-four hours of apparent health, a definite illness set in which invariably terminated fatally in from forty to sixty hours after inoculation. The first symptom was a dulness of the eye, with increased secretion from the conjunctiva, the animal became languid, ceased to eat, and finally sat still with its back bent and its legs drawn under it. Its respirations gradually became slower, and death came on almost imperceptibly. On examining it after death some local inflammation, with serous exudation, was found at the seat of inoculation, but the internal organs showed no marked change beyond some swelling of the spleen. If the point of a knife was dipped in the blood, or in the exudation at the seat of inoculation, and a mere scratch was then made with it on the ear or tail of another mouse, death invariably followed, with the same symptoms and in about the same time, and thus the disease might be transmitted indefinitely from animal to animal. A drop of the blood from an infective mouse placed on a glass slide, dried, stained with methyl-violet, and mounted in Canada balsam, was found to contain vast numbers of very delicate bacilli, about $\frac{1}{25000}$ of an inch long, and one-eighth of their length in breadth. Many of these were seen to have penetrated into the substance of the white corpuscles, and apparently to have multiplied within them.

An attempt was subsequently made to transmit the disease to other animals, but without success. Even the field-mouse, though apparently so nearly allied to the house-mouse, was found to be incapable of receiving the poison.

A general infective process was induced by Davaine in a similar way in rabbits by the inoculation of putrid fluids; but the organism found in the

blood was in that case of a different form. Both Davaine and Koch found that the infective process was more certainly induced by fluids in an early stage of decomposition.

The infective processes in this way have been described as "septicæmia" by both Davaine and Koch, but as that term is also applied to the simple chemical poisoning from putrid matter it is better to speak of the infective disease as *septic infection*, and the non-infective as *septic poisoning*.

The foregoing experiments have shown, therefore, that an acute infective process, unaccompanied by the formation of secondary centres of inflammation, can be induced both in mice and rabbits by the injection of putrid animal fluids beneath the skin.

Koch succeeded in further experiments in producing an infective disease, in which the development of secondary centres of inflammation formed a part of the process. A fluid, prepared by macerating a piece of the skin of a mouse, was injected beneath the skin of a rabbit. After two days the animal became ill, and gradually growing weaker died 105 hours after the injection. The post-mortem examination showed a diffuse purulent inflammation at the seat of inoculation, which had extended to the peritoneum; the spleen was swollen and the liver contained grey wedge-shaped patches, and dark red airless spots the size of a pea were found in the lungs. Micrococci were found in great numbers throughout the body, especially in the parts that had undergone changes visible to the naked eye. In the vessels in many parts, dense masses of micrococci mixed with red corpuscles were found adherent to the walls, and Koch felt justified in coming to the conclusion that capillary thrombi were thus produced, and that the patches in the lungs and liver were caused in this way. In the metastatic deposits, not only were the vessels plugged with mixed red corpuscles and micrococci, but the organisms had penetrated the walls of the vessels and were invading the surrounding tissues. Some blood from the affected animal injected beneath the skin of another rabbit produced essentially the same condition which terminated fatally in forty hours. The disease thus induced was, therefore, a general infective process accompanied by secondary or metastatic deposits closely resembling those met with in pyæmia in man.

Lastly, numerous experiments have been made by Cruveilhier, Sédillot, Virchow, O. Weber, Henry Lee, Savory, and many others with the view of ascertaining the part played by embolism in the production of the secondary abscesses in pyæmia. Their result has been to show, that if a fluid holding in suspension solid particles of sufficient size to lodge in the smaller arteries of the lung be injected into the blood-stream, the effect produced will depend upon whether the solid matter is irritating or not. Non-irritating emboli lodging in the terminal arteries of the lung cause the part cut off from the direct blood-supply to be intensely injected with blood. The walls of the capillaries soften and give way, and hæmorrhage takes place into the tissue of the lung. A wedge-shaped airless patch is thus formed of dark purple colour on the surface, or as it is called a *hæmorrhagic infarct*. The whole infarct is gradually absorbed without suppuration, leaving a cicatrix on the surface. O. Weber also states that very fine solid particles may pass through the capillaries of the lung and give rise to embolism in the course of the systemic circulation. Should the embolus, however, possess irritating properties, the infarct softens and breaks down, inflammation and suppuration follow in the

surrounding tissues, and thus an abscess is formed. If the irritating embolus be so small as to lodge in the capillaries only, it will directly excite inflammation and suppuration at the point at which it lodges. The experiments have shown that similar results follow whether the embolus owes its irritating properties to its mechanical condition, its chemical composition, or to its containing a specific virus. Thus abscesses in the lung have occasionally followed the injection of charcoal, and mercury. Decomposing fibrin or blood-clot or putrid fat never fail to produce them. If the emboli enter the general circulation, abscesses may form in other viscera or tissues. These observations show that the existence of secondary or metastatic abscesses does not necessarily indicate a true infective process, as the causes of the disseminated local inflammations may be carried by the blood without developing or multiplying in that fluid.

Experimental pathology has thus thrown great light upon the nature and causes of septicæmia and pyæmia, but much still remains to be explained. It will be noticed that the genuine infective diseases are associated with the presence of definite microscopic organisms which, according to the majority of modern pathologists, are supposed to stand in some direct causal relation to the process, yet they all arise from the injection of apparently similar putrid fluids. Microscopic examination shows that in the early stages of putrefaction numerous different organisms—bacilli, bacteria, and micrococci—are found in the putrid fluid; but it has not been clearly shown that each of the forms subsequently found in the blood of the affected animals is present. As putrefaction advances, the ordinary septic bacteria which, as shown by Hiller, cannot develop in a living animal, become more abundant, choking the other forms, and this fact has been suggested as an explanation of the diminished virulence of the fluid after the second day.

Septic poisoning by the chemical products of putrefaction can be produced with certainty in any animal by the injection of a sufficient dose of the putrid fluid. The symptoms produced are nearly identical in all species, though some animals, as the rodents, suffer more severely than the carnivora. On the other hand true septic infection cannot always be produced at will. The same dose of the same fluid injected into different animals of the same species may induce the disease in some and fail in others; and different species are differently affected. It is evident therefore that there are other causes dependent upon the animal itself, which are essential to the development of the infective disease, and of the nature of these we are still ignorant. When once, however, the disease is developed, it can be communicated from one animal to another of the same species with perfect certainty; but frequently it is incapable of being transmitted to animals of a different species.

Our knowledge may be briefly summarised thus: that all putrid animal fluids contain a chemical poison which, if absorbed, will cause a constitutional disturbance proportional to the dose, and that they frequently, and perhaps always, contain also a virus capable under favourable conditions of setting up a true general infective disease; and lastly, that should solid particles, as from a softening thrombus enter the blood-stream, they will, if impregnated either with the simple chemical poison or the specific virus, set up disseminated centres of inflammation and suppuration wherever they lodge. The importance, therefore, of avoiding putrefaction in the discharges of wounds cannot possibly be over-rated in the prevention of pyæmia and septicæmia.

Although the conditions in a wound in the human subject are somewhat different from those obtained in experimenting on animals, yet the analogy is close enough to justify us in applying the results obtained to surgical practice. A recent wound with decomposing discharges, or a deep cavity with pent-up putrid pus in it, are conditions essentially similar to those obtained by injecting a syringeful of a putrid fluid beneath the skin of an animal.

CAUSES OF SEPTICÆMIA AND PYÆMIA.*—Simple septic poisoning may occur whenever a sufficient quantity of decomposing blood, serum, or pus is collected in a wound or cavity of the body. Putrefaction, as before pointed out, will occur in such collections of fluid under all ordinary conditions to which a patient is exposed either in hospital or private practice. Septic poisoning affects a patient debilitated by want of proper food and bad hygienic conditions more severely than one placed under better circumstances, but beyond this the surroundings of the patient exercise but little influence on its occurrence. The causes of the process are to be looked for in the wound itself, and septic poisoning may always be prevented by efficient drainage and antiseptic treatment.

The genuine infective processes, septic infection, and pyæmia, will, on the other hand, rarely develop in spite of the presence of decomposing matter in the wound except when the patient is placed under unfavourable hygienic conditions. The experiments already described, in which septic infection and pyæmia have been artificially induced by the injection of putrid fluids beneath the skin of an animal show that the presence of decomposing matter is an important element in the causation of these diseases. Clinical experience has fully confirmed this fact. Pyæmia has been practically banished from many hospitals, chiefly Continental, in which it was formerly a frequent cause of death, merely by the adoption of antiseptic methods of treating wounds—ventilation, cubic space, and other conditions surrounding the patient being unchanged. On the other hand, a strict attention to the laws of hygiene has been equally successful in preventing these diseases even when the Surgeons have not adopted any special mode of antiseptic treatment.

These diseases are predisposed to by all conditions of life, either before or after operations or injuries, that tend to impair the health, to lower the strength, and to induce an unhealthy state of the system, such as constant want of fresh air, overcrowding in working or in sleeping apartments, abuse of alcohol, and insufficient or improper food. Of all these causes, overcrowding is undoubtedly the most frequent and the most fatal; more particularly is overcrowding of patients injurious, if many are suffering from suppurating wounds. That pyæmia is the result of the faulty hygienic conditions just alluded to, viz., want of pure air, overcrowding, and insufficient and unwholesome diet, is evident from the fact of its being most destructive where these causes of disease prevail, as amongst the poorer classes of all large and densely peopled towns; while in the purer air of country districts, or in private practice amongst the wealthier classes, it is rarely met with. It is one of those causes of death after operations that might and ought to be prevented; and wherever it is frequent, we may be sure not only that proper attention is not being paid to the prevention of decomposition and to cleanliness in the treatment of the wounds, but that either the constitutions of the patients are

* See also Chapters I. and II., and "Hospitalism and the Causes of Death after Operation." Longmans, 1874.

peculiarly deteriorated, or else that the hygienic conditions to which they are exposed after the injury or operation are more than usually faulty. That it may be prevented, has been abundantly proved by the experience gained in the Franco-German war of 1870. In that great struggle, the fact, which had been previously well known to all scientific Surgeons, was established beyond all possibility of cavil, that the danger of pyæmia increased, *cæteris paribus*, in proportion as the hygiene was faulty and as wounded patients were closely crowded, so that the atmosphere surrounding them became contaminated by fœtid exhalations from the decomposing discharges of suppurating wounds. It was found that, in the great mass of the wounded, pyæmia was developed among those who were aggregated within the walls of hospitals or regular buildings, such as churches, barns, school-houses, and conservatories, which, though clean and airy, did not admit of thorough ventilation ; while it was almost, if not entirely, absent among wounded soldiers of exactly the same class who were treated in hastily constructed open and draughty huts.

SEPTICÆMIA.

The two forms of disease known as septicæmia, septic poisoning, and septic infection, are not always to be clearly distinguished from each other in surgical practice, partly because the symptoms of the two affections closely resemble each other and partly because the true infective process is frequently complicated or preceded by the non-infective. They are sufficiently distinct, however, to justify a separate description.

Septic Poisoning, Septic Intoxication, or, as it has sometimes been called, **Sapræmia**, is the general affection produced by the absorption of a sufficient dose of the chemical products of putrefaction to endanger life. The milder effects of the same poison are classed as septic traumatic fever. Such a division as this is unscientific, and will no doubt before long be done away with, but at the present time to speak of the milder forms of septic wound-fever as septicæmia would only increase the confusion already existing.

For septic poisoning to take place it is necessary that there should be a considerable quantity of decomposing matter so situated that absorption of the poison can readily take place. The conditions, therefore, under which it is most likely to occur are large and irregular wounds, such as those resulting from compound fractures of the bones of a limb ; hollow wounds, such as those left by the removal of tumours ; wounds of joints ; wounds involving the pleura and peritoneum and large abscesses opening externally by an insufficient aperture. Perfect drainage of injuries of this kind so far limits the quantity of septic matter as to render acute septic poisoning almost impossible. Absorption takes place most readily from recent wounds, serous or synovial cavities. When suppuration has set in absorption takes place much less readily, as healthy granulations take up the poison with difficulty, unless the septic matter is pent up in contact with them at some degree of pressure.

The **symptoms of acute septic poisoning** or septic intoxication are the following. On the second day after the injury or operation the temperature rises considerably, reaching from 103° F. to 104° F., or even higher. The skin is dry, and feels hot to the hand. There may be a chill or even a severe rigor, but this is by no means constant. The patient feels very ill, there is complete loss of appetite, with headache, a quick pulse, and a dry furred

tongue. Delirium usually sets in at night, and occasionally is violent. By the third day after the injury some disturbance of the alimentary tract sets in. Vomiting is common, but diarrhœa is not frequent. In very acute cases the symptoms of collapse quickly set in. The pulse becomes rapid, feeble, and irregular, the tongue brown and dry, and the lips covered with sordes ; the temperature falls, and may sink even below normal, consciousness is lost, and the patient may become comatose before death. Dyspnœa is a common symptom during the last day. The skin may assume a yellowish tint before death. The urine frequently contains albumen.

In cases in which the septic matter which is causing the mischief is in the cavity of the pleura or peritoneum the symptoms may set in and prove fatal before the end of the third day. When the primary mischief is a large wound of the soft parts, or a compound fracture, the symptoms may be less severe and the duration of the case may extend to a week or more before death takes place. In these less acute cases the temperature is lower ; vomiting and diarrhœa are common ; there is rapid emaciation and loss of strength, death finally occurring rather from exhaustion than collapse.

In contrasting these symptoms with those produced in animals by the injection of putrid fluids beneath the skin, it will be seen that there is a general resemblance, which is quite as close as could be expected when the differences in the conditions are considered. In experimental septic poisoning the full dose is injected once for all under the skin, or into the blood ; if in sufficient quantity it is speedily fatal, if not the animal recovers. In septic poisoning, as it occurs in man, the process of putrefaction gradually developes in the putrescible matter in the wound, and the symptoms consequently are more slowly manifested. The local inflammation caused by the pent-up septic discharges is necessarily accompanied by exudation, which maintains a constant supply of fresh decomposable matter, and consequently a continuous development of the poison takes place. The symptoms are in fact as a rule the result of the prolonged administration of a moderate dose of the septic poison rather than of the sudden entrance of a fatal quantity into the blood-stream.

The **Post-mortem Appearances** are almost identical with those observed when the disease is produced artificially in animals. In extremely acute cases the signs of decomposition set in early, and the surface in a few hours after death becomes marked by lines corresponding to the superficial veins. Rigor mortis is often feebly marked. On opening the body the blood may be found imperfectly coagulated and dark in colour, but this is by no means common. A slight excess of serum, often darkly stained with the colouring matter of the blood, may be found both in the pericardium and peritoneum. The heart is flabby, and marked in many cases by small extravasations of blood (petechiæ) beneath the pericardium, usually most abundant at the back of the heart. Similar petechiæ may be found also beneath the pleura and peritoneum. On opening the heart the endocardium is found darkly stained, even at an early period after death. The lungs always show marked hypostatic congestion, their posterior part being dark purple, swollen and œdematous. The liver and kidneys are swollen and often full of blood, and the spleen is swollen and soft, sometimes almost diffluent. The mucous membrane of the alimentary canal is often congested, but with nothing approaching to the intensity met with in animals.

The post-mortem appearances are due, first to the changes in the blood, the most marked of which is the rapid disintegration of the red corpuscles, causing the staining of vessels and tissues. This disintegration takes place in extreme cases before death. The corpuscles are found not to run together in rouleaux but to form irregular clumps. This also has been observed during life, and the blocking of the vessels by these masses of corpuscles is probably the cause of the capillary hæmorrhages found throughout the body. Secondly, there is a marked tendency to passive congestion of the viscera consequent on the feeble action of the heart before death; and, lastly, there is cloudy swelling of the epithelium of the glandular viscera.

In more chronic cases of septic poisoning similar changes are found, but less marked in proportion to the chronicity of the case.

Diagnosis.—Septic poisoning can be confounded only with some malignant specific fever, but the distinct connexion of the symptoms with their cause is in most cases so evident that an error is scarcely likely to be made. In former times many cases of septic poisoning after operations were classed as collapse, or exhaustion.

Prognosis.—The prognosis depends upon the severity of the symptoms and the possibility of removing the cause. If the accumulation of septic matter can be cleared away and its re-accumulation prevented, cases apparently hopeless may sometimes recover.

Treatment.—The treatment consists in removing the cause, as by laying a joint freely open, enlarging the aperture in an imperfectly opened abscess, or establishing good drainage in a cavity, as the peritoneum or pleura, or in a wound. The occurrence of septic poisoning can generally be prevented by antiseptic treatment, and efficient drainage. The patient's strength must be kept up by stimulants and liquid food.

SEPTIC INFECTION.—An acute general disease accompanied by symptoms closely resembling those just described as resulting from septic poisoning is not unfrequently met with in circumstances which preclude the possibility of its being due merely to the absorption of a chemical poison. The conditions which would lead us to believe that a given case is the result of a true infective process are, first, its arising from a wound of such size as to render it impossible for the necessary dose of septic matter to be formed in it; secondly, evidence of infection from one patient to another; and, thirdly, the presence of active living organisms in the blood. The first condition is met with in those cases of septicæmia that follow the inoculation of the poison of dead bodies, by a scratch or puncture during a post-mortem examination. In these the local inflammation may be very slight, the patient dying rapidly from blood-poisoning. Similar cases are sometimes met with after operations in which the wound is too small to furnish a fatal dose of the chemical products of putrefaction. The second condition, infection from another patient, is seldom observed in surgical practice. It is, however, very marked in the septicæmia which forms one of the varieties of puerperal fever, the fearful infectiousness of which is but too well known. The last condition, the presence of specific organisms in the blood, has been observed in many cases of septicæmia, but our knowledge on this subject is at present very imperfect when compared with that which we possess with regard to septic infection in animals. It must be remembered, however, that until recently the non-infective and infective forms of septicæmia were confounded together,

and the methods of observation have only lately been brought to any degree of perfection.

Those cases of septic infection which arise as a consequence of large wounds, the discharges of which are in a state of decomposition, are necessarily complicated to a greater or less degree by septic poisoning, and the recognition of the infective process then becomes correspondingly difficult.

Although, therefore, at present we are unable always to separate septic poisoning and septic infection in actual practice, it is to be hoped that further observation will enable us to do so, for the importance of the distinction is very great. Septic poisoning is not infectious, and can be relieved by removing the local source of the septic poison; septic infection, on the other hand, is supposed to be intensely contagious, and may be readily communicated from one patient to another, and as it is a general or blood-disease no relief can be expected from treatment applied to the local source of infection.

Symptoms of Septic Infection.—The disease is usually ushered in by a distinct rigor, often severe, and sometimes repeated more than once. The temperature rapidly rises, reaching 104° F. or 105° F., or even a higher point, during the rigor. The subsequent symptoms closely resemble those already described as occurring during septic poisoning. There is delirium, ending in insensibility, and even in profound coma. The pulse is extremely rapid and quickly becomes feeble. The tongue rapidly becomes dry and brown, and the lips and teeth are covered with sordes. Diarrhœa or vomiting may occur. The skin assumes a yellowish tint, and purpuric spots may appear on the skin. The temperature may fall and become subnormal before death, or may remain high to the end. Dyspnœa is often a marked symptom before death.

In very acute cases death takes place on the second or third day after the commencement of the disease, but life may be prolonged even for a week.

The **post-mortem appearances** are the same as in septic poisoning; visceral congestions, subserous petechiæ, early and intense post-mortem staining, and usually a swollen and softened spleen. In some cases there is pneumonic consolidation of the lung, and there may be pleurisy with blood-stained effusion. Microscopic organisms have been recognized in the blood in many cases, but at present the disease has not been shown to be associated with a definite form, as in the corresponding affections produced experimentally in animals.

Diagnosis.—In the present state of our knowledge it is frequently impossible to distinguish septic infection from septic poisoning except in the definite absence of the cause of the latter condition, as in some poisoned wounds. Septic infection is identical in its symptoms and post-mortem appearances also with the malignant forms of the acute specific fevers in which the patient dies before the characteristic eruption appears, and unless the source of infection is evident the diagnosis may be very doubtful.

Prognosis.—The uncertainty of the diagnosis necessarily interferes with an accurate prognosis; but when the evidence is strong that the affection is a genuine infective process the case is almost hopeless.

Treatment.—If the case is complicated by a septic wound means must be taken to remove the septic matter and clean out the cavity with some strong antiseptic solution, as of chloride of zinc (40 gr. to ℥j), or carbolic acid (1 in 20). The patient's strength must be supported by fluid nourishment, and stimulants and quinine may be given in large doses.

PYÆMIA.

Pyæmia is merely a clinical expression for a general disease originating in a local source of infection, and accompanied by the formation of disseminated centres of inflammation and suppuration throughout the body. It most commonly, in fact almost invariably, arises as the secondary result of a primary inflammation which has reached the stage of suppuration, and the name was derived from the theory that the disease was due to the entrance of the pus into the blood stream, or "purulent absorption." It has however been clearly proved that healthy fresh pus may be injected freely into the blood stream without giving rise to the affection known as pyæmia. The disease is now believed to be due to the entrance into the blood-stream of a specific poison developed in unhealthy or decomposing pus. Although in the great majority of cases in which pyæmia comes under the observation of the Surgeon it occurs as a complication of wounds or injuries in which the discharges are in a state of putrefaction, this is not invariably the case. Thus, in the disease known as acute necrosis of bone, pyæmia often sets in before the sub-periosteal abscess has been opened, and when the pus is perfectly free from any signs of decomposition. The primary disease in this case is however itself an infective process, and not a simple inflammation. Simple healthy abscesses never give rise to pyæmia till air has been admitted from without at the time they are opened or burst. Pyæmia is frequently met with as a consequence of other specific suppurative inflammations; thus, we see boils, carbuncles, diffuse cellulitis, and phlegmonous erysipelas often precede and lead to its occurrence.

Pyæmia was formerly a very common cause of death after surgical operations and injuries, especially those implicating the veins, bones, or joints. The improved hygienic condition of most hospitals, and the introduction of antiseptics and drainage in the treatment of wounds have almost banished it from surgical practice. In properly constructed and well regulated hospitals and in private practice it is rarely met with except as a complication of cases in which efficient antiseptic treatment is impossible, as in operations on the urinary organs, or as a sequence of some specific inflammation, as carbuncle, acute necrosis, or scarlatinal inflammation of the fauces.

In some rare cases the symptoms and post-mortem appearances of pyæmia are met with without any primary inflammation being found. These cases have been described as idiopathic or spontaneous pyæmia.

The nature of the poison and its mode of entrance into the system will be discussed with the pathology of the disease.

Pyæmia is characterized especially by two series of phenomena: 1. A peculiar train of Constitutional Symptoms attended by a state of great depression of the powers of the system; 2. The formation of Abscesses, and the occurrence of diffuse inflammations in various parts of the body. The disease may be acute, subacute, or chronic. Most usually it is subacute, and often chronic. Whatever form it may assume, the symptoms are essentially the same, differing only in degree.

Symptoms.—The invasion of the disease is as follows: During the period of apparently ordinary febrile disturbance, the patient is seized with a rigor, usually very severe and prolonged. The rigor presents no difference from that met with in the invasion of many other specific febrile affections (p. 183)

except in its severity. In some cases of pyæmia the rigor is not repeated, but more frequently it recurs at irregular intervals of from twenty-four to forty-eight hours ; and, as the disease becomes established, even twice or oftener in the day. A single rigor, although a very alarming symptom, may pass off without the development of the disease. The subsequent sweating is very profuse, the bedclothes being soaked with the perspiration. These rigors are necessarily very exhausting to the patient.

The *temperature* in pyæmia presents remarkable and characteristic fluctua-

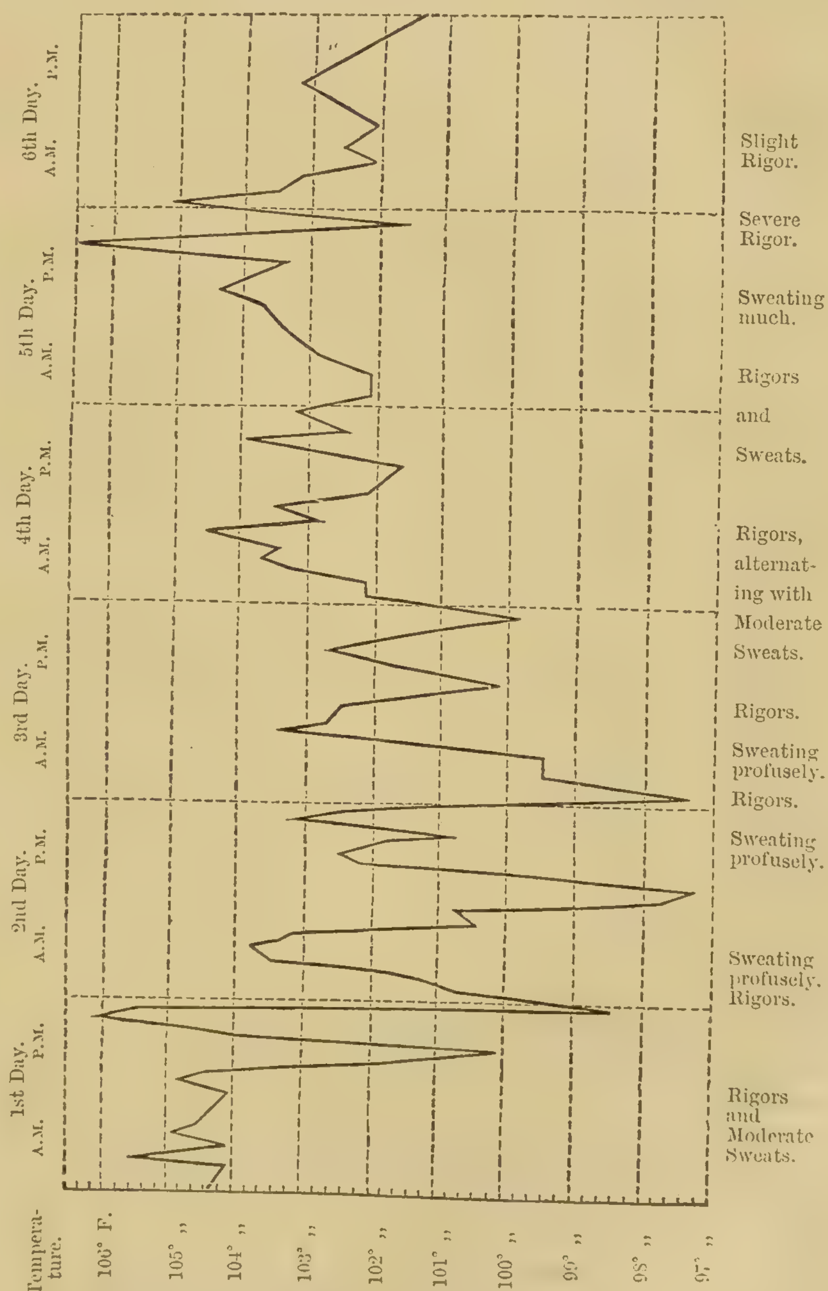


Fig. 355.

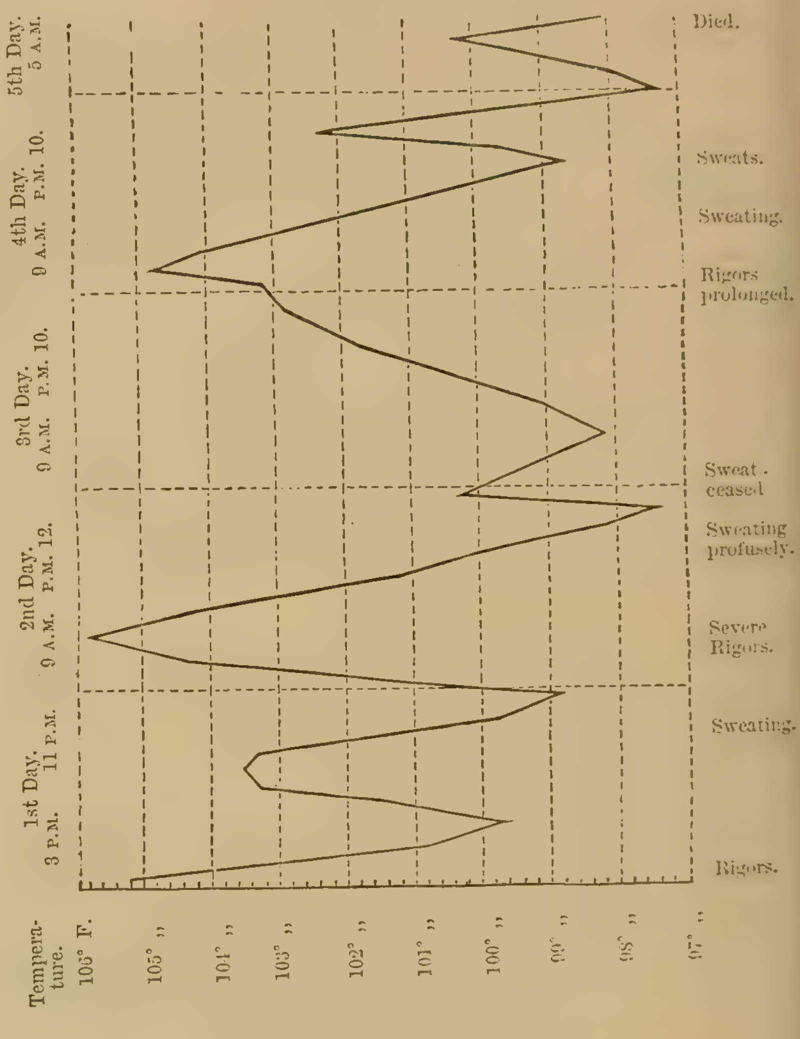
Temperature Chart in a case of Pyæmia following Primary Amputation of the Foot in a man aged 30.

tions. It is uniformly higher than normal, but rises and falls in its general level in exact accordance with the development of the rigors. The accompanying Diagrams (Figs. 355, 356), for which I am indebted to Dr.

Ringer, who took them from patients of mine, will indicate this more clearly than any description. Wunderlich observes that the rise of temperature in the first accession of pyæmic fever is greater in a shorter time than in any other disease, and that the fall is equally rapid with the rise, and sometimes more so. But it does not, as a rule, reach the normal point, and usually

Fig. 356.

Temperature Chart in a rapidly fatal case of Pyæmia following a Compound and Comminuted Fracture of the Bones of the Leg.



ascends again long before this is reached. In some cases, however, the temperature falls slightly below normal during the profuse sweating following a rigor, as shown in the accompanying temperature charts. The rise in the temperature precedes the occurrence of the rigors; and the approach of a rigor may be predicted by noting a commencing rise in the thermometer. There are sometimes actually two rigors during one continuous rise of temperature.

Should the rigors recur with some degree of regularity the pyæmia may closely resemble an attack of ague. As a rule, however, the regular periodicity so characteristic of ague is wanting in pyæmia. After the occurrence of rigors other changes begin to manifest themselves.

Any open wound that may exist is usually in an unhealthy state at the time

of the invasion of the disease. It is either foul, or sloughy, or inflamed, and discharging decomposing pus, which perhaps does not find a ready exit. Even when the wound appears healthy superficially, it is probable that some pus is deeply pent up within it, or that possibly, if the bone is injured, inflammation and suppuration are taking place in the medulla. Pyæmia never arises from a healthy superficial granulating sore. When pyæmia has set in, the wound usually becomes dry and ceases to discharge pus. Even if the superficial parts remain tolerably healthy, the granulations become pale and healing ceases. In very chronic cases, however, healing may go on while the patient is still suffering from secondary abscesses in different parts of the body. The skin is continuously hot, and has often a burning pungent feel. The breath has that peculiar sweetish, saccharine, or fermentative smell that is commonly noticed in all febrile diseases of a low type ; this odour of the breath, and indeed of the body generally, often occurs early in the disease, and must then be taken almost as a diagnostic and certainly as a most unfavourable sign. The secretions are arrested ; the pulse is quick and soft ; the face is usually pale, with a very anxious drawn look, but sometimes flushed, and the eyes bright ; there are hebetude and dulness of mind, with slight nocturnal delirium, but perfect consciousness on being spoken to. Rapid wasting of the body sets in about this period ; patches of erratic erythema frequently make their appearance on the surface ; and the skin assumes a dull sallow and earthy, or a bright yellow icteric tint, which may extend to the conjunctivæ. The symptoms now indicate an extreme depression of the vital powers ; the pulse becoming small and fluttering, the tongue, which has been dry, becoming brown, sordes being deposited about the teeth, and low delirium supervening. Usually from the sixth to the tenth day, but sometimes earlier, suppuration commences in different tissues, joints, and organs.

The **Formation of numerous centres of inflammation and suppuration**, "secondary or metatastic abscesses" as they are termed, is the most marked feature of pyæmia. The pus in these abscesses is often thin and oily-looking ; sometimes, however, it is thick and laudable. In the oily-looking pus the cells are extremely granular, and sometimes so far degenerated that no nucleus can be recognized even after the addition of acetic acid ; the liquor puris contains large quantities of granular débris. In some cases the pus has been observed to form a firm coagulum, and occasionally it is fœtid. These purulent collections vary greatly in size and in situation. They are found in the viscera, in the intermuscular and subcutaneous areolar tissue, in the serous cavities, in the joints, and occasionally in the muscles, or at the seat of subcutaneous injuries received at the same time as the wound from which the infection has taken place.

Pyæmic abscesses differ from ordinary purulent collections, not only in the peculiar character of the pus that they contain, but more particularly in the rapidity with which they form, a few days commonly sufficing for them to attain a large size. This, with their very widely spread character, and the insidious manner in which they occur, often with few if any local signs, constitute the distinguishing features of these collections.

The visceral abscesses vary in size from a pin's head to a walnut ; in many cases the organs affected are studded with them. These collections are most frequently met with in the lungs, being seated at the posterior part and on

the surface of these organs, or in the interlobular fissures. They form often without cough or pain, and the area of consolidation is rarely sufficiently extensive to be recognized by percussion. They are usually rapidly followed by pleurisy with effusion, which conceals any physical signs of the mischief in the lung-tissue. The organ that is most frequently affected next to the lung is the liver. Here also the abscesses are usually small and numerous. They can occasionally be recognized by irregularity of the surface of the liver in the superficial part in the epigastrium and by tenderness on pressure. Jaundice often forms a marked symptom. In some cases, especially when the disease is secondary to dysenteric ulceration of the intestine, the abscess is single and of considerable size. Secondary abscesses are not uncommon in the spleen, where they can only occasionally be recognized by tenderness and pain in the splenic region. They are met with, with some frequency, also in the kidney, less commonly in the brain, and, in rare cases, in the parotid gland, the prostate, and testes.

Inflammations of the serous membranes in pyæmia are usually secondary to abscesses of the viscera, but they are occasionally met with independently. There is usually abundant effusion, which rapidly becomes purulent. The pleura is most commonly affected, the peritoneum least frequently. The symptoms of these serous inflammations as a rule present nothing peculiar except in the rapidity with which effusion takes place.

The joints are frequently affected, especially the knees and shoulders. They become rapidly filled with a thin yellowish purulent liquid. This is usually indicated by intense pain, often cutaneous or superficial, with fluctuation and swelling in the joint. Often, however, large accumulations of pus form suddenly in joints, without having been preceded by pain or any other sign of mischief; in these cases the interior of the joint, though filled with pus, remains tolerably healthy, there being no erosion of cartilage or destruction of ligament, but merely some inflammatory injection of the synovial membrane.

When the pus is infiltrated into the areolar tissues and muscles of the limbs and trunk, it forms diffuse collections of a thin serous matter, commonly mixed with shreds of the areolar membrane of the part, having no boundary. These collections are met with in the axilla, down the flank and about the back, in the iliac fossa, thigh or calf, and may either be confined to the subcutaneous, or extend to the deep intermuscular, areolar planes in these regions; or they may form even in the muscular substance itself, being diffused between the fasciculi, which are softened and disintegrated. Most commonly the presence of these collections is indicated by patches of cutaneous redness, and by a doughy, œdematous, and boggy state of the superjacent integuments. Sometimes superficial patches of redness with some œdema appear in different parts of the body, afterwards subsiding without the formation of pus, giving rise to one form of the condition known as "erratic erysipelas."

Amongst the rarer complications of pyæmia is acute suppuration of the eyeball, or *metastatic panophthalmitis*, as it has been termed. All the structures of the globe are affected. Virchow has shown that it is due to the lodgment of infective emboli in the vessels of the eye. Litten and Leube have observed retinal hæmorrhage in many cases of puerperal pyæmia. In some cases they appeared to be the result of embolism, but in others this seemed doubtful.

Plugs of micrococci have been observed in the retinal vessels after death. These conditions are met with only in very grave cases, and usually indicate the approach of death. The ophthalmoscope may therefore sometimes furnish valuable evidence both of the nature of the disease and its probable termination.

The progress of the disease is usually from bad to worse, sometimes rapidly, but at other times not uninterruptedly so, there being remissions and apparent, though not real, improvement. The patient rapidly wastes, the body becoming shrunken, the muscles soft, and the skin gray or sallow, loose and pendulous ; great debility also sets in. The abdomen becomes tympanitic, diarrhœa or profuse sweats come on ; pneumonia or pleuritic effusions declare themselves ; delirium, from which the patient is easily roused, alternates with sopor ; and at last he sinks from exhaustion. Death takes place usually about the tenth or twelfth day ; though it may occur as early as the fourth, or the patient linger on for six or seven weeks.

Post-Mortem Appearances.—The body is usually emaciated and rigor mortis is feebly marked. The skin is generally yellowish in tint, sometimes intensely jaundiced. Purpuric spots are occasionally noticed on the surface, especially in the lower extremities. Decomposition as a rule sets in early.

Appearances at the Seat of Infection.—Any external wound is usually gray, sloughy, or dry, and the parts round it may be œdematous. If the wound be one implicating the bones, as an amputation, or an excision of a joint, it very frequently presents the appearances of septic or gangrenous osteo-myelitis. The exposed end of the bone is bare, and the periosteum is loosened. If the shaft of a long bone has been implicated the medullary canal contains gangrenous fat mixed with offensive pus ; if the cancellous tissue has been opened up the spaces are filled with a similar material. (See Osteo-myelitise, Vol. II.) In the bones of the skull the diploë may be found infiltrated with pus.

The **Veins** leading from the wound are in some cases perfectly healthy ; far more commonly, however, they are found to present marked evidences of disease. While exposing the vein by dissection it will usually be noticed that the areolar tissue in its neighbourhood is infiltrated with inflammatory products for a considerable distance from the wound, and occasionally the vessel may be surrounded here and there by pus. When the vein is exposed, it is seen to be distended, in parts dark purple, and in parts yellowish, as if filled with pus. On opening the vein its coats are found to be swollen and thickened, and its lumen filled with a thrombus in various stages of softening and disintegration. This thrombus may extend for a great distance, as from the leg to the groin, its extremity sometimes projecting into the main trunk, into which the affected vein enters. The fragments of the softened thrombus may thus be carried on into the circulation as emboli, lodging in the lungs and giving rise to secondary abscesses. In some cases the source of the secondary mischief may be recognized by the state of the veins. Thus in cases of osteo-myelitis, the thrombosis of the main trunk may commence at the point at which the veins from the bone enter it. In a case in which a patient died of pyæmia after an amputation of the thigh in University College Hospital, the veins leading from the stump were perfectly healthy, while those leading from a foul bed-sore were full of disintegrated clot.

General Post-Mortem Appearances.—The **blood** may be dark in

colour and imperfectly coagulated, as in septicæmia, but in the vast majority of cases presents no naked-eye abnormal appearance.

The **Veins** of distant parts are occasionally found to contain softening thrombi similar to those observed at the seat of infection. In the 110 cases of pyæmia collected by the Committee of the Pathological Society this condition was observed in six. These cases are of great interest as indicating that the general infection of the blood may, in some cases at least, be an important factor in causing thrombosis at the original seat of infection.

Secondary Centres of Inflammation occurred in the following order of frequency in the 110 cases reported in the Transactions of the Pathological Society of London, 1879. The table is divided into two columns, A and B, A showing the frequency with which the secondary inflammation was limited to one organ or tissue, and B, the number of cases in which the special part was affected in combination with others.

	A.	B.	Total.
Joints	12	8	20
Subcutaneous and intermuscular areolar tissue	4	8	12
Muscles	0	1	1
Bruises and other subcutaneous injuries	1	1	2
Serous membranes	6	4	10
Lung	33	24	57
Liver	1	11	12
Spleen	1	10	11
Kidneys	0	6	6
Brain	1	5	6
Heart, substance of	1	4	5
Endocardium	0	1	1
Parotid gland	0	1	1

The cases of inflammation of serous membranes do not include those in which the mischief was merely secondary to abscesses in the organs they cover. The relative frequency of the affection of the different membranes was as follows: pleurisy, 4; meningitis, 3; pericarditis, 2; peritonitis, 1.

The **Heart** is frequently the seat of small extravasations, which may be found either beneath the pericardial or endocardial lining, or in the muscular substance itself. Sometimes, though not very often, abscesses are found situated either in the wall or in the papillary muscles; these are usually small collections of puriform matter, rarely much larger than a pea, and often surrounded by a zone of congestion or hæmorrhage. The muscular substance is flabby, and the lining membrane of both the heart and aorta is usually more or less deeply stained by imbibition of the colouring matter of the blood. Pericarditis may occur independently or in connection with metastatic abscesses in the heart, or may be secondary to the inflammation of the pleura. Occasionally diffuse acute inflammation of the muscular structure of the heart is found, without any distinct abscess having been formed.

The **Lungs** are much congested, especially at the posterior bases, where the tissue is friable; sometimes this congestion passes into true pneumonia. The most important condition present in these cases is the existence of *metastatic abscesses*, which may vary much in number and size. These are commonly found scattered over the surface, and are most common in the upper part of the lower lobes, and the interlobular fissure. Their position is indicated by induration and a slight elevation, to be felt on passing the hand over the

surface of the lung. It occasionally happens that all stages of development of the "secondary abscesses" may be observed in the same lung. The earliest stage is merely the effect of embolism. A small terminal artery having been obliterated by an embolus, the wedge-shaped portion of lung it supplies becomes intensely engorged with blood by regurgitation from the surrounding parts; the walls of the vessels soften and hæmorrhage into the lung-tissue and air-vesicles takes place. The portion of the lung-tissue then presents the ordinary appearance of so-called pulmonary apoplexy; it is dark red on section, like damson-cheese, airless, and solid, but breaking down readily on pressure. The consolidated portion is spoken of as a "*hæmorrhagic infarct.*" If this were due to the lodgment of an unirritating embolus, the extravasated blood and the tissues which have been deprived of their blood-supply, would be gradually absorbed, leaving a depressed cicatrix in the lung tissue. In pyæmia, however, the embolus is infective and intensely irritating; consequently the vessel in which it is lodged sloughs, and the mischief extending to the surrounding tissues, the whole infarct softens and breaks down. The products of this process soaking away into the surrounding lung-tissue cause inflammation, with exudation into the air-vesicles identical in its pathological appearances with ordinary croupous pneumonia. Occasionally all these conditions may be recognized in one infarct. On making a section through it a gray or yellowish fluid may be seen in the centre; it is not pus, being produced by gangrenous softening of the central parts of the infarct. Round this is a zone of pulmonary apoplexy, then follows a paler solid area, having the ordinary appearances of pneumonic consolidation, and round this again a zone of hyperæmia, in which the vesicles still contain air. As the area of softening extends, the cavity becomes a true abscess, containing pus mixed with the *débris* of the tissues of the lung, and the wedge-shaped form is then lost. The size of these abscesses varies greatly, from less than that of a pea to two or three inches in diameter. The pleurisy which accompanies, and in most cases results from, the formation of the abscesses is often very severe. The pleural surface is thickly covered with patches of inflammatory lymph, whilst quantities of deeply coloured turbid fluid are usually collected into the pleural sac. Sometimes, though rarely, small collections of pus are found scattered through the substance of the organ without affecting its pleural surface, or giving rise to any of the wedge-shaped masses above described.

The **Liver** frequently presents no abnormal appearances, even in severe cases, where the lungs have suffered most markedly; in others, again, it is the seat of many abscesses, which often attain a very large size. They have much the same character, both as to form and position, as those in the lungs, and are usually surrounded by a zone of hæmorrhage and congestion. When, however, they occur without any deposits in the lungs preceding them, they may appear as simple collections of pus, having a more or less branched arrangement. This form of pyæmic abscess does not appear to be the result of arterial embolism. In cases in which the general blood-poisoning is more marked than the local effects, the liver is found to be swollen, its structure is soft and more friable than usual, and its colour uniform and muddy. The epithelium is found on microscopic examination to be excessively granular.

The **Spleen** is usually large, soft, very friable, and often of an almost pulpy

consistence. Infarcts unconnected with the pyæmic state are frequently met with in this organ ; metastatic abscesses are not, however, very common.

The **Kidneys** are almost invariably swollen and soft ; the epithelium cloudy, excessively granular, and often choking the tubules in irregular masses. They are very frequently congested, and sometimes the seat of abscesses presenting the same varieties as those found in other parts.

The **Intestines** rarely suffer, but abscesses may be found in the submucous or subserous areolar tissue. Local peritonitis not unfrequently follows the formation of hepatic abscesses, and may become very severe. Of the other organs the **brain** is most commonly affected.

Diffuse suppuration is occasionally met with in the **parotid gland**, and in rare cases abscesses have been observed in the **prostate**.

One or more **Joints** are frequently found to be swollen, and on opening them a large quantity of pale yellow or thick, flaky, and puriform fluid escapes. There are congestion of the synovial fringes, and softening or destruction of the cartilage.

MICROSCOPIC APPEARANCES OF TISSUES AND ORGANS IN PYÆMIA.—The blood in almost all cases contains a considerable excess of white corpuscles, with a deficiency of red, but this condition is by no means peculiar to or characteristic of pyæmia. The red corpuscles are usually unchanged ; but, occasionally, they have been observed to run together into irregular masses instead of forming rouleaux.

Microscopic organisms have been frequently observed in the blood, and these will be more fully referred to afterwards.

The yellowish fluid found in the veins as the result of softening of the thrombi closely resembles pus in appearance, but on microscopic examination it is found in many cases to be composed merely of granular débris containing no true pus cells. In other cases, as I have frequently observed, cells having the ordinary appearance of pus-cells are more or less abundantly present.

The so-called " secondary deposits " may in an early stage in like manner be found not to contain pus, being composed merely of gangrenous tissue. In the later stages pus is always present.

The epithelium of the liver and kidney is usually granular and swollen.

Microscopic Organisms.—In almost all cases of pyæmia, micrococci can without difficulty be recognized in various situations.

At *the seat of infection* they are frequently found in large quantities in the discharges, and in the slough that so frequently covers the surface of the wound. They are always present in the *fluid resulting from the softening of the thrombi* in the veins. In the *blood* they are recognized with greater difficulty, and the evidence as to their presence has been very conflicting. Throughout all other parts of the body they have been observed *in the purulent fluids in the secondary abscesses*, but their most characteristic appearance is as colonies or zooglœal masses blocking the *smaller arterioles or capillaries.* In this form they are readily recognized in sections prepared in the ordinary way, and stained with logwood or methyl violet. They form rounded granular masses, in which it is often difficult to recognize the individual organisms except at the edge of the mass. The vessel is slightly distended at the part at which they are lodging, and there is occasionally seen a coagulum above and below the obstruction. Sometimes the wall of the vessel appears to have given way, and the organisms are found outside it. In most specimens no

change is observed in the tissues around the vessel, but occasionally inflammatory exudation has taken place, and the group of micrococci seems to form the centre of a commencing abscess. These colonies of micrococci are found in the lymphatic glands nearest to the seat of infection, in the liver, heart, thyroid body, and especially frequently in the tufts of vessels in the Malpighian bodies of the kidney. The accompanying drawings (Figs. 357, 358) copied from the Transactions of the Pathological Society of London, 1879, and from Koch's

Fig. 357.—A colony of micrococci lying amongst the muscular fibres of the heart. (From Path. Soc. Trans. 1879.)

work on Infective Processes in Wounds, show very clearly the appearances presented by the micrococci in pyæmia.

General Pathology.—On contrasting the symptoms and the post-mortem appearances just described with those observed in the diseases experimentally produced in animals (see p. 935), it will be seen that they closely resemble, if they are not identical, with them. In those cases in which a softening thrombus is found in a vein, and the secondary abscesses in the lungs only, the conditions are identical with those obtained by injecting putrid matter containing coarse solid particles in suspension into the veins of an animal. In other cases the disseminated abscesses, with capillary thrombosis and the distribution of colonies of microscopic organisms throughout the system closely resemble the results obtained by Koch from the injection of putrid fluids beneath the skin of a rabbit. In the human subject the conditions under which the disease arises also closely resemble those obtained experimentally in animals.

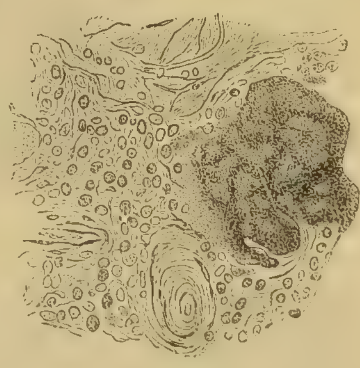


Fig. 358.—Colony of micrococci, from a lymphatic gland. (Path. Soc. Trans. 1879).

The thrombosis which forms so frequent a precursor of pyæmia, is predisposed to by all those conditions which favour thrombosis in general (see Diseases of Veins), but it is usually determined in one of two ways. In many cases an unhealthy diffuse inflammation spreads upwards from the wound in the areolar tissue surrounding the vein. This periphlebitis leads to inflammation of the coats of the vessel followed by coagulation of the contained blood. The clot becoming impregnated with the products of the unhealthy inflammation, softens and becomes disintegrated. In other cases, the thrombus forms in the vein either in consequence of its having been divided and ligatured, or from death of the tissues from which it derives its blood, as in necrosis of bone. If under these

circumstances the distal end of the thrombus becomes exposed to septic matter, as in a foul wound, the clot decomposes and disintegrates. The presence of the decomposing clot causes inflammation of the vein, and an extension of the thrombus; the new clot in its turn decomposes, and thus the process extends up the vein almost indefinitely. In whichever way the spreading thrombosis takes place, it may continue to extend till it reaches a point at which the affected vessel joins another large trunk, when the softened fragments may be washed on into the circulation, and cause the effects already described wherever they lodge.

In some rare cases the cavity of a foul abscess may open directly into a large vein by ulceration of the wall.

In those cases in which decomposing discharges are pent up in a deep

Fig. 359.—Micrococci, plugging a small branching arteriole in the muscular fibre of the heart. The tissues round are infiltrated with inflammatory exudation. (Koch.)

wound, the conditions are essentially analogous to those which exist when putrid fluids are injected beneath the skin, as in Koch's experiments.

The explanation of the pathology of pyæmia may therefore be fairly sought in the experimental investigations which have already been described. The part played by the microscopic fungi is still open to dispute, but the opinion is steadily gaining ground that they take some essential part in the causation of the disease. That in all cases a true infective process is developed in which a specific poison enters the blood and multiplies in it is not proved. In some cases, in which the secondary abscesses are limited to the lungs, it is possible to explain all the phenomena by supposing that the fragments of a putrid clot enter the blood-stream, and lodging in the lung, cause a number of embolic abscesses which may prove fatal without any general infection of the blood.

Varieties of Pyæmia.—In the preceding pages a description has been given of the general symptoms and post-mortem appearances of pyæmia. The disease, however, does not always run the same course, and a few definite varieties may be mentioned.

Acute Pyæmia.—In this form the rigors are well marked, the fever is high, secondary abscesses form early, and almost invariably affect the viscera; death takes place usually before the tenth day. Acute pyæmia is found after death to be almost constantly associated with softening thrombi in the veins, and embolic abscesses. It is most common after operation or injuries involving the bones, as amputation or compound fractures, and is frequently preceded by septic osteomyelitis. It is invariably fatal. The part taken by embolism in the production of the secondary abscesses is often so evident in this form that it has been described as *embolic pyæmia.*

Chronic Pyæmia.—In this form of the disease the fever is less intense; there may be but a single rigor, but occasionally it may be repeated frequently throughout the case. The secondary inflammations affect chiefly the subcutaneous cellular tissue and the joints, and occasionally the pleura, the viscera not being affected. Sometimes the secondary abscesses appear at points exposed to pressure, as the shoulders, or elbows, or the back; in other cases suppuration takes place in subcutaneous injuries, as bruises or simple fractures. The patient may linger on for weeks, and finally die from exhaustion; or recovery may take place, leaving him in shattered health, with perhaps one or more joints firmly ankylosed. Chronic pyæmia is most frequently met with after injuries of the soft parts, especially the genito-urinary organs, and it forms a not uncommon form of puerperal fever. It has been known to follow gonorrhœa, and is allied to some forms of "gonorrhœal rheumatism." Should the patient die, as a rule no softening thrombi are found in the veins.

Umbilical Pyæmia is a name which has sometimes been given to a form of the disease occurring in infants from thrombosis of the umbilical vein, with subsequent softening of the clot.

Pyæmia without an Open Wound.—This may occur as the result of ulcerations of the alimentary canal, as in typhoid fever or dysentery, or as a consequence of some infective inflammation of a deep part. A general febrile disease with rigors, and the formation of metastatic abscesses has been observed also as a complication of gonorrhœa. Perhaps the most common example of pyæmia from a subcutaneous inflammation is the form that so frequently follows acute necrosis of bones in children. This is an acute infective inflammation terminating rapidly in the formation of pus beneath the periosteum. It is very frequently complicated by thrombosis of the veins leading from the bone, and subsequent softening of the thrombi and embolism. The emboli are impregnated with the infective products of the local inflammation, and wherever they lodge they give rise to abscesses. It is not known with certainty what is the exact nature of the infective material either in pyæmia from an open wound, or in acute necrosis, but in both cases it is disseminated throughout the system by the blood-stream, and consequently the anatomical distribution of the secondary centres of inflammation will be the same even if the virus is different.

Idiopathic Pyæmia is a term applied to those rare cases in which the symptoms during life and the post-mortem appearances are those of pyæmia, and yet no local source of infection can be found.

Mixed forms of Pyæmia and Septicæmia.—Although these diseases have been described separately, it must not be supposed that they are always met with in actual practice distinct from each other. In most cases of pyæmia the patient suffers at the same time more or less severely from septic

poisoning; the early blood-staining, the soft and swollen spleen, the sub-serous petechiæ, and the other characteristic signs of that condition form prominent features at the post-mortem examination. In other cases, with the exception of an unhealthy wound, a softening thrombus in the vein, and some softening infarcts in the lungs, the post-mortem appearances may be those of a healthy body. Between these extremes every variety may be met with. It is this that has led some Surgeons to the conclusion that septicæmia and pyæmia are mere modifications of a single process.

Prognosis.—The prognosis in pyæmia is always bad. The disease is dangerous to life, to health, and to limb. When active acute pyæmia has fairly set in, recovery rarely, if ever, takes place, the patient usually dying between the fourth and the twelfth days. One or two rigors may occur, and yet the patient may recover. Each repetition of the attack adds to the gravity of the case. In fact, the danger and the rapidity of the fatal termination in any given case will, *cæteris paribus*, depend on the frequency of the rigors and their severity.

When the pyæmic attack is from the first subacute or chronic, it may be recovered from, usually after prolonged illness, the formation of numerous or large abscesses, and great and continued disturbance of the general health.

In these less active and acute forms of pyæmia, the joints are liable to special implication, more particularly the knee and elbow. Destructive suppuration may be set up in it, and loss or permanent impairment of utility of the limb will be the inevitable result.

Diagnosis.—The diagnosis of pyæmia requires to be made :—1, from ordinary Surgical Fever, the Inflammatory Fever which accompanies wounds and Injuries, and Typhoid Fever ; 2, from Ague ; 3, from Rheumatism ; 4, from Septicæmia.

1. The **Diagnosis from ordinary Surgical Inflammatory Fever and Typhoid Fever** is usually sufficiently easy, the course of these fevers being unbroken by severe rigors, by sudden fluctuations of temperature, or by sweats. These symptoms, which are characteristic of pyæmia, do not occur in these other forms of febrile disturbance. An ordinary fever may be ushered in by a rigor ; but this is seldom so intense as that which marks pyæmia, and certainly does not recur during the attack. The temperature also in ordinary fevers is more uniform. It is not marked by those sudden exacerbations, followed by equally rapid declines, that are so characteristic of pyæmia.

2. From **Ague** the diagnosis would not be easy in the earlier stages, if the patient had been exposed to malarial influences, and was at the same time suffering from surgical fever resulting from a wound, as then the characteristic feature of intermittent fever, the prolonged period of normal temperature between the rigors, will be wanting. Thus in a person injured whilst living in a malarial country, there may be much doubt as to the nature of the attack ; but in large towns, the general absence of ague and the obvious surgical cause of the pyæmia will render the diagnosis more easy. In the later stages, the signs of articular inflammation and suppuration, the secondary visceral and areolar abscesses, will all tend to clear up the diagnosis. In any doubtful case a chart should be made of the temperature when the regular periodicity of the attacks in ague will be very apparent if that disease is present.

3. From **Rheumatism** it is easy to make the diagnosis of pyæmia, provided

the recurrent rigor and other early symptoms have been well and strongly marked. But if these have been somewhat obscure, and if the secondary articular implication be early developed, then it may certainly be difficult to determine the exact disease with which the patient is affected. But, independently of the recurrent rigor, the great prostration, the early supervention of atonic symptoms, the development of the visceral abscesses, of areolar suppuration, and of patches of erratic erysipelas, will establish the true nature of the disease. Moreover, the temperature of rheumatic fever does not show the extraordinary variations seen in pyæmia and the sweating in rheumatism is continuous, and not merely the sequence of a rigor. In pyæmia the tongue is usually dry, and perhaps brown, and never presents the creamy white fur characteristic of rheumatism. The smell of the patient is sweet or "saccharine" in pyæmia, while in rheumatism it is sour; in either case, quite distinctive.

4. From **Septic Poisoning** and **Septic Infection** it is not always possible to make the diagnosis. In fact, as before stated, pyæmia is in the majority of cases more or less complicated by septic poisoning. In septic infection the acute symptoms, the single rigor, the marked signs of blood change, such as the icteric tint, the dyspnœa, and the early insensibility and the absence of secondary inflammations, may serve to distinguish the nature of the case; but in many cases the diagnosis is almost impossible during life.

TREATMENT.—The *Preventive Treatment* is *Local* and *General.*

The **Local Preventive Treatment** consists in preventing the accumulation of decomposing discharges in the cavities of wounds or abscesses. This is effected, first, by properly draining the cavity in such a way that an accumulation of decomposable matter is impossible; and secondly, by employing antiseptic agents in the dressing in such a way as to prevent even the slightest trace of putrefactive change in the discharges. It is evident that in many operations about the throat, rectum, and genito-urinary organs these principles cannot be fully carried out. In certain specific inflammations, as in infective endocarditis, or acute necrosis of bone, the inflammatory products possess infective properties independently of any contamination from the external air; and if they enter the blood-stream they may give rise to embolism of distant parts with softening of the infarcts and suppuration around them. Pyæmia cannot, therefore, be entirely banished from surgical practice, but it can be limited to a few exceptional cases. The experience of all surgeons who have adopted the antiseptic treatment of wounds, has shown beyond a doubt that in all such cases as amputations, excisions of joints, recent compound fractures, removal of tumours, and the like, pyæmia is preventable, that it can and should be entirely excluded, even from hospital practice.

The **General Means for the Prevention of Pyæmia** consist in a scrupulous attention to those hygienic measures which have been described in the earlier chapters of this work; and above all to a careful avoidance of *over-crowding.* Overcrowding is, however, a relative term; if, as must often happen in military practice, efficient antiseptic treatment is impossible, pyæmia is certain to break out though but a small number of patients are accumulated in a limited area; on the other hand, if decomposition of the discharges can be prevented, a larger number may be treated in the same space without danger. No wise Surgeon would, however, on this account neglect the well-known laws as to cubic space, free ventilation, and general cleanliness, relying

solely on antiseptics to prevent contamination of the air. It has already been pointed out in the early chapters of this work, that although putrid discharges are the most dangerous and most powerful source of contamination of the atmosphere of a surgical ward, the products of respiration, and the accumulation of excreta, will alone so vitiate the air as to impair the health and lower the vitality of those that breathe it; and thus delay the healing of wounds and favour the development of infective diseases.

A **Curative Treatment** of pyæmia can scarcely be said to exist. It doubtless happens that patients occasionally recover from this disease, even after the formation of diffuse abscesses; but such a result must be looked upon as a happy exception to its commonly fatal termination, rather than as the result of any special mode of treatment. The only treatment that holds out any hope of success, appears to me to be the stimulating and tonic one, consisting of alcoholic stimulants, tonics, and liquid nourishment; in fact, that treatment which is usually adopted in low fevers and unhealthy inflammations. I have certainly seen service done in some cases, and indeed recovery follow the administration of large doses of quinine; five grains being given every third or fourth hour, with the best effect. Among many others, I may mention a very serious case of pyæmia following amputation of the arm, and accompanied not only by all the symptoms of that disease in a very marked degree but by pleuritic effusion, swelling and tenderness over one hip, and secondary hæmorrhage from the stump, which recovered under the tonic and stimulating plan of treatment. The quinine appears to check the rigors and to reduce the temperature. In some cases I have administered the chlorate of potash largely (ʒ ij. to ʒ iv. in the day), in addition to the quinine and wine, with apparent benefit. If the depression be very great, carbonate of ammonia in five or even ten grain doses may be given; such fluid nourishment as the patient will take, a liberal allowance of alcohol, wine, or porter, being also administered. In addition to this medicinal treatment, hygienic measures must be put in force. The patient should throughout be placed in an airy and well-ventilated apartment, and all hygienic rules carefully attended to.

As abscesses form, they must be freely opened. This should be done with antiseptic precautions, as the pus in the secondary abscesses is not in a state of putrefaction, and the patient's condition will be greatly aggravated if it be allowed to decompose. In cases arising as the consequence of septic osteomyelitis following amputations or compound fractures, removal of the limb at the next joint above the affected bone has been recommended and successfully practised by Sir J. Fayrer, even after one or more well marked rigors.

If convalescence take place, the patient will slowly recover. The rigors and sweats will gradually become less frequent; the appetite will improve: the countenance will lose its anxious expression, and the skin its unhealthy hue. But strength returns slowly. The disease may assume a relapsing character. Great caution, therefore, is necessary before a patient can be pronounced safe. Even after recovery he will continue pale and wasted; energy is lost; nutrition is impaired; and at a more remote period some low form of disease, as phthisis or albuminuria, may prove fatal. These evils are best prevented by a course of sulphureous mineral water, followed by a long sea-voyage.

CHAPTER XXXIV.

TUMOURS.*

The frequency with which *Tumours* fall under the observation of the Surgeon, the great variety in their characters, and their important relations, local as well as constitutional, render their consideration one of great moment. According to Hunter, a tumour is "a circumscribed substance produced by disease, and different in its nature and consistence from the surrounding parts." This definition, though not perhaps accurately correct in some forms of tumour, which do not differ in their nature from neighbouring parts, is yet clinically convenient. By a tumour may also be meant a more or less circumscribed mass, growing in some tissue or organ of the body, and dependent on a morbid excess of, or deviation from, the nutrition of the part. Cornil and Ranvier define a tumour as a "mass composed of a tissue of new formation (a neoplasm) having a tendency to persist or to increase." Lücke defines it as an "increase in size from the growth of new tissue, by which no physiological end is gained." These growths may therefore be considered under the two heads of local hypertrophies, or outgrowths of the normal structure of the part; and of new formations, presenting structural characters which differ more or less widely from those of the parts around. The tumour thus formed increases in size by an inherent force of its own, irrespectively of the growth of the rest of the system, but still obeys the same laws of growth which govern the body generally. In order to constitute a tumour, it is necessary that the normal form of the part be widely departed from; a mere increase in its size, so long as it preserves its usual shape, being scarcely considered in this light. Thus if the tibia be uniformly enlarged to double its natural size, the enlargement is a hypertrophy; but if a comparatively small rounded mass of bone project directly forwards from its tuberosity, it is said to be a tumour and not a mere hypertrophy.

Classification of Tumours.—A classification of tumours may be founded either upon their anatomical structure, or upon their vital and clinical characters; and although these two systems will in most cases, lead to a similar grouping of individual growths, yet our knowledge is at present too imperfect to enable us to point out in every case the connection between clinical history and histological structure. Surgeons have long divided tumours into two great classes—the **Non-malignant** and the **Malignant.** This division, however, though practically convenient, is not scientifically exact. Although some tumours, as the cancers, are always and essentially

* The most exhaustive treatise on this subject is Virchow's great work, "Die Krankhaften Geschwulste" (the Pathology of Tumours), whilst in his "Cellular Pathology" will be found an exposition of his views of the development of new formations. The reader will find in Paget's classical "Lectures on Surgical Pathology" the best account in the English language of the clinical characters of these growths. He may also consult with advantage Rindfleisch's "Histolegical Pathology" (translated for the New Sydenham Society by Dr. Baxter), Billroth's "Surgical Pathology" (American Edition), and the "Manuel d'Histologie pathologique," by Cornil and Ranvier, vol. i., 2nd edit. I am under much obligation to my friend, Mr. Godlee, for his kindness in having undertaken the illustration of this chapter with a series of drawings from nature, which are alike admirable for their fidelity and their artistic merit.

malignant, and others as uniformly benign, as lipomata and some cysts, yet many others that are usually innocent may, under certain conditions, take on a truly malignant action : this has led to the establishment of an intermediate group that may be termed the **Semi-Malignant**.

The **Non-Malignant, Innocent**, or **Benign Tumours** are strictly local in their development, and are rarely connected with any constitutional or hereditary peculiarity. They resemble more or less completely the normal textures of the part in which they grow, and hence are very commonly, though not perhaps with strict propriety, termed *homologous*. They usually, though not invariably, grow slowly, are more or less distinctly circumscribed, being often enclosed in a cyst or loose capsule of connective tissue, and have no tendency to involve neighbouring structures in their own growth ; any change that they induce in contiguous parts consists simply in displacement or atrophy by their size and pressure. They are usually single, but not unfrequently multiple, developing either simultaneously or successively ; but if in the latter mode, without any connection with preceding growths. If removed by operation, they do not return ; but if left to the ordinary processes of nature, they slowly attain a great size, remain stationary, and, at last, atrophy, decay, or necrose.

The essentially **Malignant Tumours** differ widely from those just described. They cannot be considered as simply local diseases ; if local in the first instance, they have a tendency rapidly to affect the constitution, and to reproduce themselves in distant parts of the body. They are usually characterized by extreme vegetative luxuriance, but by a somewhat low vitality, being prone to early decay ; the peripheral parts being usually in a state of active growth, while the central are undergoing fatty degeneration, ulceration, or gangrene. They represent an extreme departure from the ordinary nutrition of the part ; and, when once formed in an organ or tissue, they develop by an inherent force of their own, irrespectively of neighbouring parts, producing masses which differ in structure and appearance from anything observed in the normal condition of the tissues in which they grow ; and hence they are called *heterologous*. This term, however, cannot be considered strictly accurate ; inasmuch as the microscopic elements of which the masses are composed have their several analogues in the normal structures of the body. But though the individual constituents of the tumour may be normal, their aggregation and mode of arrangement are totally abnormal, and differ from everything met with in a healthy state of the tissues. The mass, which may either be infiltrated in the tissues, or localized, increases quickly in size. As it increases in size, it tends to implicate the neighbouring structures in its own growth, and to affect distant parts through the medium of the lymphatics or the blood. If removed by operation it has a great tendency to return in its original site or elsewhere, though it does not necessarily do so. If left to run its course, a malignant tumour will inevitably soften, necrose, and ulcerate, often with much pain, profuse hæmorrhage, and the induction of a peculiar state of cachexy, which speedily terminates in death.

The following may be looked upon as the principal *characteristics of a malignant growth*.

1. The tumour, whether arising spontaneously or as the result of external violence, whether occurring in an individual in whom there has existed an hereditary tendency to similar or to allied disease, or in one whose pro-

genitors have never evinced any tendency to similar affections, is invariably at first small, and is usually defined, with a distinct outline.

2. There is a constant tendency to extension of the disease by local infiltration and absorption of neighbouring structures; not only by their mere absorption by the pressure of an increasing growth, but by their actual incorporation into its substance followed by their destruction, and the development of the morbid mass in their place.

3. This process continues uninterruptedly; in many cases slowly, as in scirrhus of the breast; in others, in special forms of disease and in certain situations, as in encephaloid of the testis, very rapidly.

4. The rapidity of the growth of the tumour, and of the absorption and infiltration of the neighbouring structures, is usually in the measure of and in proportion to the malignancy of the affection.

5. There is no limit to the size of the growth; but when it reaches a certain point of development, its central parts undergo fatty degeneration, and in some cases a sort of cicatricial contraction. When it reaches the surface, it speedily sloughs or ulcerates towards its centre, giving rise to profuse discharge usually offensive in character, and not unfrequently to abundant hæmorrhage. Even during this stage, its circumference continues to grow and to invade the surrounding parts. Thus a progressive destruction of the surrounding tissues takes place. This tendency to destroy the part in which the original growth is developed is spoken of as the local malignancy of the tumour.

6. At a certain period—early in some cases, and not until many months have elapsed in others—secondary growths make their appearance in different parts of the body. These are due to the cells of the tumour finding their way either into the lymphatics or the blood-vessels, and lodging in distant parts. In some malignant tumours, as in the true cancers, the lymphatic glands which receive the lymph-stream from the tumour are always affected first; in others, as in most sarcomas, the lymphatic glands escape, the earliest secondary growths appearing in the lungs or liver. In the true cancers the internal organs are affected after the glands. The secondary growths are of essentially the same structure as the primary tumour, though differing occasionally in minor details. They serve as new foci for the dissemination of the disease, and usually assume a more active character than the primary affection to which they owe their origin. This general affection of the system is spoken of as the *general malignancy* of the tumour. Some forms of tumour show very great local and but slight general malignancy, others great general malignancy but slight local. The cancers usually show intense general and local malignancy.

7. After the development of the secondary growths the patient exhibits evidences of serious modifications in nutrition and sanguification. The body wastes, the skin becomes sallow, the digestive powers become impaired, and anæmia supervenes.

9. They cause death in one of the following ways:—from the exhausting effects of the discharges, and hæmorrhages from the local and primary disease; from special visceral disturbances induced by the secondary growths; or from malnutrition and consequent cachexy.

From the above it will be seen that although the cancers form by far the greater proportion of malignant tumours, *malignant* and "*cancerous*" are not synonymous terms. Every malignant tumour is not a cancer, though every

cancer is a malignant growth. Some tumours occasionally present the clinical characters of malignancy, though structurally they are intimately related to others which are usually looked upon as essentially non-malignant; and we are thus obliged to consider, that these terms are merely relative, and that these two great classes pass into one another by insensible gradations. It will be subsequently seen that the sarcomas and some cartilaginous tumours stand in this intermediate position between the more typical examples of these two great groups. Those apparently benign tumours which have a tendency to recur after removal, and thus to run as it were a locally malignant course, are usually very rapid in their growth and development. Indeed, great rapidity of growth may usually be looked upon as evidence either of malignancy, or of liability to speedy recurrence after extirpation. In some cases, after repeated removals, the tendency to recurrence appears to wear out, and the patient eventually overcomes the disease. But in other instances this fortunate result does not occur. Where tumours of any kind recur after removal, it will often be found that the secondary differs in some respects from the primary growth. Thus it may be found to be softer, more vascular, and more diffused. In microscopical structure, it may be found to present evidences of greater activity of growth, and to depart more widely from the normal type.

Paget makes the important observation that tumours, apparently similar in structure, may run very different courses in different individuals, in some being in every way innocent, and in others malignant. Thus a tumour, composed purely of spindle-shaped cells, may in one case show no tendency to recur after removal, or to affect distant parts; whilst in another it may not only infiltrate surrounding tissues, but give rise to secondary growths in internal organs. Paget makes also the very interesting practical remark, which agrees entirely with the result of my own observation, that the children of cancerous parents may be the subjects of tumours not carcinomatous in structure, but closely resembling such growths in the rapidity of their progress, their liability to ulcerate and to bleed, and their great disposition to return after removal.

The term **Semi-malignant** may be employed to include those growths which occupy the doubtful position indicated above: it must, however, be distinctly understood that this term cannot be employed in any very definite sense.

Innocent and malignant tumours are occasionally met with in the same person, four or five different kinds of growth even occurring in one individual. I have seen in one patient a scirrhous breast, enchondromatous tumour of the leg, and an atheromatous cyst on the back, with scrofulous glands in the neck. New formations of different types may be found even in the same mass: thus, encephaloid cancer and spindle-celled sarcoma have been found together in the testis. This, however, must not be taken as any evidence of the possibility of the conversion of one into the other, but rather as the result of a departure in different directions from the normal mode of growth. There is indeed no proof that a non-malignant can be converted in any circumstances into a malignant tumour of a different type: a fibrous tumour may take on rapid growth and assume the characters of a malignant sarcoma, at last destroying the patient, but there is no evidence that it can ever be changed into a cancer. A malignant tumour may, however, appear on the site of a non-malignant growth that has been removed: thus I have seen a scirrhous

nodule grow in the cicatrix left after the removal of a cystic sarcoma of the breast.

Besides these various forms of tumours, others are met with, of a constitutional and specific character, such as those that occur in connection with scrofula and syphilis; but these are usually looked upon in this country rather as modifications of chronic inflammation than as tumours.

A **classification founded upon an anatomical basis** not only enables the observer to comprehend the precise relation which any particular growth under observation bears to others that resemble it; but it leads him to trace the origin of the new formation from the pre-existing structures of the part in which it occurs, thus forming the first step towards a knowledge of the etiology of the disease. Tumours are said to be *heterologous* or *homologous*, according as they present a greater or less deviation from the normal condition of the tissues from which they spring. These terms are essentially relative; and it is only to instances at the extreme ends of the series that either term can be definitely applied. At the same time it must be borne in mind, that Virchow's law holds good even for the most heterologous growths; this law states, that "the same types of anatomical structures exist in new formations as are found in the body generally," and he thereby denies the possibility of the occurrence of a true heteroplasia, and the existence of specific elements in new formations, differing from any normal cells in the body. The more heterologous the growth, that is, the greater the departure from the normal structure of the part in which it occurs, the more malignant, as a rule, will be its action upon the system generally; whilst the reverse, with some exceptions is true of homologous formations.

In classifying tumours according to their anatomical structure, they are divided primarily into four chief groups. First, those composed of one of the forms of connective tissue; secondly, those composed of tissue resembling one of the higher tissues of the body; thirdly, those composed of embryonic tissue, either pure or developing into connective tissue; and, fourthly, those in which epithelium forms the essential part of the growth. Cystic tumours are classed by themselves, forming a fifth group.

General Characters of Typical Tissues.—Before proceeding to consider the individual growths, which are thus grouped together, it will be desirable to describe briefly the essential features presented by the structures upon which the types of some of the classes are founded.

First as to **connective tissue**:—This exists throughout the body, presenting, however, many varieties of form adapted to the special functions of each particular part in which it appears. It consists essentially of an intercellular substance, homogeneous, hyaline or fibrillated, in which are embedded cells having an oval, caudate, fusiform, or branched form, and usually presenting a distinct central nucleus and nucleolus. In addition to these, in fibrous or areolar tissue, wandering cells, with amœboid movements, are normally present. These are regarded as white corpuscles, which have migrated from the vessels. The fixed connective-tissue-corpuscle was looked upon by Virchow and his followers as the starting point from which are derived the various cell-structures, entering into the formation of all tumours. Other pathologists have believed that connective tissue tumours might arise by the growth and development of leucocytes which have migrated into the affected part. At the present time, whatever part may be ascribed to leucocytes in

the formation of new tissue as a consequence of inflammation, they are not supposed to take any share in the growth of tumours of the connective tissue type.

The following are the chief forms of connective tissue: areolar tissue, adipose tissue, white fibrous tissue, yellow elastic tissue, bone, and cartilage. Mucous tissue must also be included under the same type. It is met with in the Whartonian jelly of the umbilical cord and in the adult only as the vitreous humour of the eye.

The simplest form of **embryonic tissue** is composed of small round cells about the size of white blood-corpuscles, connected with each other by a small quantity of homogeneous intercellular substance. The cell consists merely of a small mass of protoplasm with a nucleus in the centre, which is usually somewhat difficult to distinguish. The vessels in such tissue are abundant, and extremely thin-walled, like those of granulations. The modifications in this tissue observable in tumours are seen both in the cells and in the intercellular substance. The cells may be of great size, almost resembling epithelial cells; they may be spindle-shaped, oval, or stellate. The intercellular substance may be small in quantity and amorphous, or it may be increased in amount without apparent change in its nature. The most common modification is a development of fibrous tissue between the cells. It must be remembered, however, that, in tumours classified under the type of embryonic tissue, with very rare exceptions, a recognizable intercellular substance, either homogeneous or fibrous, extends between the individual cells, and this serves as an important point of distinction between some modifications of embryonic tissue and epithelium.

Epithelium is composed of cells united together by a homogeneous material or cement, which is not sufficient in quantity to be recognizable under ordinary circumstances. No vessels ever penetrate amongst the cells, nor do the fibres of the surrounding or subjacent connective tissue extend between the individual elements. Consequently if, on washing a microscopic section so as to remove the cells, a reticulate fibrous stroma is seen forming spaces in which single cells have lain, the tissue is not epithelial. It will be seen hereafter that some forms of tumour, composed of one of the modifications of embryonic tissue, may so closely resemble epithelial growths that it is only by carefully observing a washed specimen that the distinction can be made. Epithelium-cells vary much in shape and size, and their outline is sharply defined. They possess usually one nucleus, sometimes two, with one or more highly refracting nucleoli. The nucleus is frequently eccentric. The form of epithelium met with in a primary tumour is always similar to that normal to the part in which the tumour is growing; thus in the skin it is squamous, in the intestines columnar, and in glands it is spheroidal. In secondary tumours, the type of epithelium corresponds to that of the primary growth. Primary tumours containing epithelium never originate except in connection with parts in which epithelial cells are normally present. This fact has led to another classification, according to the origin of the part in which the tumour grows, from one or other of the three layers into which the blastoderm divides in the first stages of development. From the superficial layer or epiblast are developed the central nervous system, the organs of sense and the cuticular covering of the body, and the glands of the skin: from the lower layer or hypoblast arise the epithelial lining of the air-passages, and of the alimentary canal with the epithelial

lining of ducts opening into it, and the special epithelium of the glands themselves. The rest of the body arises from the middle layer or mesoblast. It is supposed that, after this early differentiation of the embryonic cells, the tissues which belong to one layer can never be developed from the cells of another. Thus tumours, such as cancers, in which epithelium forms the active and essential element, can never develop primarily in those parts which arise from the mesoblast. Tumours have, therefore, been classified as epiblastic, mesoblastic, and hypoblastic, but the distinction is of little practical importance.

The following classification may be adopted as possessing clinical convenience, and, at the same time, presenting, as far as possible, an anatomical uniformity.

I. Cystic Tumours generally.

II. Tumours composed of one of the modifications of fully developed Connective Tissue.

a. Fat—Lipoma.
b. Fibrous Tissue—Fibroma.
c. Cartilage—Chondroma, Enchondroma.
d. Bone—Osteoma, Exostosis.
e. Mucous Tissue of Umbilical Cord or Vitreous Humour—Myxoma.

III. Tumours which resemble in structure more or less perfectly one of the more Complex Tissues of the body.

a. Muscle—Myoma.
b. Nerve—True Neuroma.
c. Blood-vessels—Angioma, Nævus.
d. Lymphatic Vessels—Lymphangioma, Lymphatic Nævus.
e. Lymphatic Glands—Lymphadenoma.
f. Papillæ of Skin or Mucous Membrane—Papilloma.
g. Secreting Glands—Adenoma.

IV. Tumours composed of Tissue which is either purely Embryonic, or is showing some signs of a tendency to develop into adult tissue of the Connective type.

Sarcomata.—These are subdivided chiefly according to the shape and size of the cells of which they are composed; thus, round-celled, oval-celled, spindle-celled, giant-celled sarcoma, &c.

V. Tumours composed of Cells of an Epithelial Type, arranged in spaces in a stroma consisting of more or less perfectly developed fibrous tissue.

Carcinomata or true Cancers.—Scirrhus, Encephaloid, and Epithelioma.

Ætiology of Tumours.—In the great majority of cases we have not the remotest idea of the causes which have led to the growth of the tumour. Hereditary tendency has a marked influence in the growth of many forms, more especially of malignant growths. The cancers are certainly inherited in a large proportion of cases; in simple tumours hereditary tendency is less marked, but is occasionally to be traced. Local irritation or mechanical injury is undoubtedly the determining cause of the growth of the tumour in a certain proportion of cases. The effects of this cause also are most marked in malignant growths. The proportion, however, in which such a cause can be traced is very small, varying, according to different authors, from 14 to 7 per cent. Cohnheim has suggested the hypothesis that some tumours may arise from the minute portions of embryonic tissue which have persisted in an

undeveloped state amongst the mature tissues ; but there is little definite evidence to support the theory.

CYSTIC TUMOURS.

A **Cyst** is defined as a cavity of new formation, or resulting from the abnormal distension of a natural space, surrounded by a more or less distinct wall, and filled with fluid or semi-solid matter. The wall of a cyst is lined by epithelium or endothelium, or has no definite lining, according to its origin. The accurate classification of cysts is difficult, because conditions which are pathologically similar are clinically spoken of as cysts in some parts of the body and not in others. The method usually adopted is that in which they are divided according to their mode of origin, as follows :—

1. Cysts arising from the distension of pre-existing spaces.
2. Cysts of new formation.
3. Congenital cysts.
4. Parasitic cysts.

1. Cysts arising from the distension of pre-existing spaces.—These are subdivided into : (*a.*) Exudation-cysts ; and (*b.*) Retention-cysts.

(*a.*) **Exudation-Cysts** arise from chronic exudation into cavities which are not provided with excretory ducts, as, for instance, the bursæ, which often attain a considerable size in these circumstances. Strictly speaking, chronic synovitis, with "dropsy of the joint," hydrocele of the tunica vaginalis, and spina bifida, should be included in this class, but clinically these affections are never spoken of as cysts. A form of exudation-cyst is sometimes met with in connection with serous and synovial membranes, which arises from a hernial projection of the membrane with subsequent constriction and obliteration of the neck of the protrusion, so that a separate cyst is formed. Some of the cysts met with in the popliteal space, and of those formed in connexion with the sheaths of tendons, or *ganglia*, are supposed to be formed in this way. Similar cysts are occasionally met with in one of the situations of abdominal hernia, which are evidently formed by the constriction and obliteration of the neck of the sac of the peritoneum, with subsequent exudation into the closed cavity.

In cysts formed in connection with synovial membranes or bursæ, opaque, white, or yellowish bodies, resembling melon-seeds in size and form, are not unfrequently met with. Sometimes these are attached to the cyst-wall by a narrow pedicle, but more often they are free. They are supposed to arise in three ways : first, as an outgrowth from the cyst-wall ; secondly, by changes taking place in extravasated blood ; and lastly, from a fibrinous exudation from the wall of the cyst. The presence of blood-crystals, which has been recognized in some cases, proves that they occasionally arise in the second way. The symptoms and treatment of these affections are described with diseases of bursæ (see Vol. II.).

One form of *cystic disease of the ovary* may be placed under this head, as it arises from dilatation of the Graafian follicles. The cysts are usually numerous, but do not individually reach any very great size. They contain a serous fluid, and ova have been recognized within them, thus proving their origin.

(*b.*)—**Retention Cysts** arise from an obstruction to the escape of some

natural secretion, in consequence of which the acini, or tubules, of the gland become expanded, or the duct becomes dilated to such an extent as to form a distinct cyst. The process by which the cyst is formed is not one of simple dilatation ; it is accompanied by a new growth of fibroid tissue, resulting from the irritation caused by the tension of the retained secretion, so that in almost all cases the wall of the fully developed cyst is many times thicker than the structure from which it originated. If the cyst springs from a duct, the walls of which contain involuntary muscular fibre, this will be found to have disappeared, the new tissue being purely fibrous. The cyst-wall is lined with epithelium of the same character as that naturally lining the cavity from which it has originated. The contents may still resemble the natural secretion, but more commonly they are altered by degeneration and inspissation, or by exudation from the wall of the cyst.

Retention cysts may be divided into three groups : (α). Atheromatous cysts ; (β). Mucous cysts ; and (γ). Cysts from the dilation of large ducts. The two first groups are also spoken of as "follicular cysts."

(α). The **Atheromatous Cysts** are those arising in connection with the hair or sebaceous follicles ef the skin. The minor forms of obstruction to the ducts of the sebaceous follicles give rise to the condition known as comedo and molluscum, which are not generally classed with cysts.

Atheromatous Cysts are usually situated upon the scalp, face, neck, or back ; sometimes, however, they occur elsewhere—thus I have removed a very

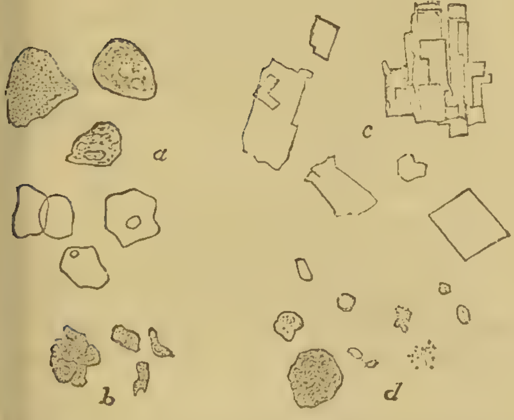


Fig. 360.—Contents of Atheromatous Cyst (454 diam.).
a. Epithelial cells undergoing various degrees of fatty degeneration.
b. The same with calcareous degeneration.
c. Crystals of cholesterine.
d. Oleaginous and fatty particles.

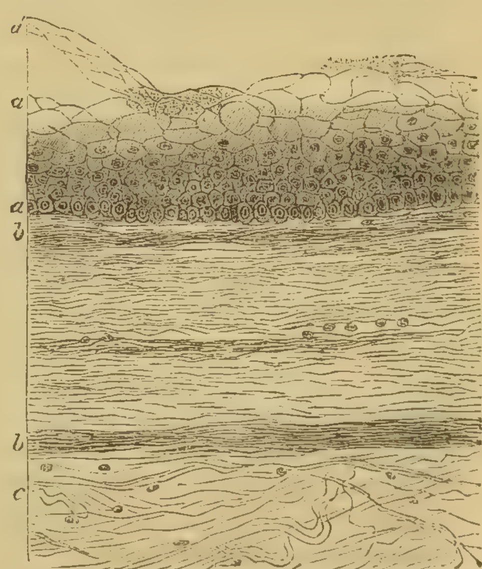


Fig. 361.—Wall of Atheromatous Cyst (188 diam.).
aa. Epithelial lining, the superficial cells swollen and fatty.
b. A flake of fatty cells peeling off.
bb. Fibrous capsule.
c. Surrounding connective tissue.

large one from the fore part of a girl's arm, and others from the labia and groin. The size of these tumours varies from that of a pin's head to an orange ; the smallest occur on the eyelids, the largest on the shoulders and scalp. They have been met with also on the palmar aspect of the fingers, a situation in which hairs and sebaceous follicles are usually absent. Their origin then is uncertain, as it is doubtful if they can arise from sweat glands. Athero-

matous cysts are often very numerous, especially about the head, where as many as thirty or forty may be met with at the same time. Most frequently they form in women about the middle period of life: they are smooth, round, or oval, movable under the integument, either semi-fluctuating or elastic, though sometimes solid to the touch. In some parts where the sebaceous follicles are large, as on the back, a small black point can often be detected on the surface of the tumour, through which an aperture may be found leading into its interior, and allowing the expulsion of its contents. A sebaceous tumour consists of a cyst-wall and contents. The cyst-wall is composed of dense white fibrous tissue, having elongated connective-tissue-corpuscles scattered through it. It is connected to the surrounding parts by loose areolar tissue, containing yellow elastic fibres in some abundance. The thickness of the wall varies greatly. When the cyst is situated on the hairy scalp it will always be found to be tough and thick, while in all other situations it is much thinner. Immediately in contact with the inner surface of the cyst-wall, a layer of actively growing epithelial cells is found closely resembling the deeper layers of the epidermis; further from the wall these assume a distinctly squamous form; then they become filled with fat granules, and finally break down into a fatty granular mass (Fig. 361). The atheromatous mass forming the contents of the cyst is composed of this fatty debris. If examined when freshly removed from a tumour, it will be found to be soft, creamy, pultaceous, or sometimes cheesy-looking, of a yellowish white colour. Sometimes in old cysts it becomes dry and laminated, looking not unlike Parmesan cheese. In some cysts of old standing and large size, the contents may be semi-fluid, the more liquid parts being a brown, green, or blackish tint. These various contents are essentially composed of sebaceous matter, mixed in various proportions with epithelial scales, fat-granules, and cholesterine (Fig. 360). Sometimes the cyst-wall is found to send fibrous septa towards the centre of the cyst, apparently representing the remains of the tissue between the acini of the follicle; but true papillæ or hair-follicles are never found in cysts due to obstruction of the excretory ducts of a sebaceous follicle. Occasionally a part of the cyst-wall may undergo calcification, and calcareous particles may be found among its contents (Fig. 360, b.). Malherbe has described a true ossification of the cyst-wall with calcification of the epithelium cells. This is rare, and the tumours have been described as osteomata of the skin before their true nature was understood. Some forms of cysts of new formation closely resemble those just described in their contents and naked-eye appearances, but differ from them in the structure of their walls, which is that of true skin. These will be referred to again under "dermoid cysts."

Progress.—The growth of these tumours is often very slow; but not unfrequently, after remaining stationary for years, they increase rather rapidly. The tumour itself, though painless, may give rise to uneasy sensations, by compressing nerves in its vicinity; it usually continues to grow slowly, until the patient, being annoyed by its presence, has it removed by operation. If left untouched, it occasionally, though rarely, happens that the sebaceous matter, exuding through an aperture on its surface, forms a kind of scab or crust, which by a process of sub-deposition becomes conical: and, being gradually pushed up from below, at the same time that it assumes by exposure a dark brown colour, forms an excrescence that looks like a horn, and is usually considered to be of that character. These "horns" have been met

with on the head, on the buttock, and in other situations. The accompanying drawing (Fig. 362) is taken from a child four years old, brought to me to have its horn removed; a woman also once applied to me with one about an inch and a half long, growing from the upper lip.

In other cases, these tumours inflame and suppurate; the skin covering them becomes adherent and reddened, ulceration takes place, and, if the cyst be small and dense, it may be thrown off by suppuration in the surrounding tissues. If it be larger, ulceration of the integuments covering it takes place, and the sebaceous matter is exposed; this may then putrefy, become horribly

Fig. 362.—Horn on Nose of a child.

Fig. 363.—Ulcerated Encysted Tumour of Scalp.

offensive, and break away in unhealthy suppuration. In other cases, peculiar changes take place in the cyst-wall: large granulations are thrown out in it, and the cyst-wall appears to vascularize, becoming irregular and nodulated, rising up in tuberous growths with everted edges, exuding a fetid, foul discharge, becoming adherent to subjacent parts, and assuming a malignant appearance, forming at last a sore as large as a saucer (Fig. 363), and then resembling epithelioma.

Cysts that have undergone this change show great local malignancy, rapidly infiltrating and destroying the surrounding parts, but as a rule the lymphatic glands are not implicated. I have seen a case in which the skin was destroyed from a little below the vertex, to the root of the neck, and from ear to ear transversely. The surface was covered with fungating granulations, but there was no implication of the glands. Lücke states that in such cases a genuine transformation of the atheromatous cyst into an epithelioma has taken place, the epithelium penetrating the cyst wall and growing in the tissues beyond. It most commonly occurs after middle life.

Diagnosis.—The only diseases with which these tumours can be confounded are abscesses and fatty growths. From an *abscess* an encysted sebaceous tumour may be distinguished by its history, slow growth, situation, elasticity, and mobility, and the existence of the dilated orifice of the sebaceous duct, through which some of the contents can be squeezed, the microscopical examination of which will serve to confirm the diagnosis. From *fatty tumours* these growths may be diagnosed by their firmer and more regular feel: and in case of doubt, by the evacuation and examination of their contents. Sometimes

the cysts may be lobulated so as closely to resemble a fatty tumour (Fig. 364). But even in these cases they may be distinguished by the Surgeon pressing on the edge of the tumour ; if cystic it will remain fixed, and the finger can be pressed through it ; if a lipoma it will roll away. When this cyst has become epitheliomatous, its origin can be ascertained only from the history.

The *Treatment* of a tumour of this kind consists simply in its removal, after which it is never reproduced, unless a small portion of the cyst-wall have been left behind. So long as these tumours are small, and do not give rise to deformity or inconvenience, they may be left without surgical interference. But when large, and more particularly when they have become inflamed, they should be removed. The method of operation will vary according to their situation and the thickness of their walls. When situated on the scalp, where

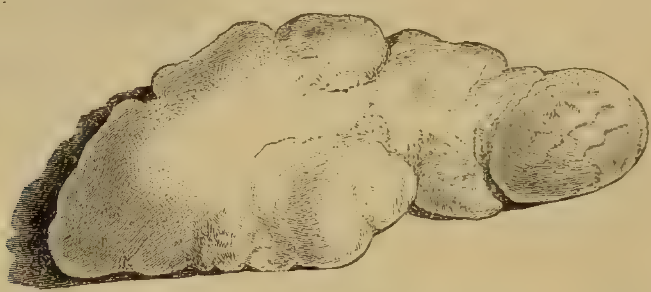


Fig. 364.—Large Atheromatous Cyst from the Back, simulating Fatty Tumour. (Half the natural size.)

the cyst is dense and tough, the tumour may very readily be removed by transfixing it and the skin covering it with a scalpel, squeezing out the atheroma, and then seizing the cyst-wall with forceps and pulling it out. In this little operation there are two points that require attention : first, the base of the cyst should never be transfixed ; and, secondly, no attempt at dissection should be made : if either of these precautions be neglected, troublesome hæmorrhage may ensue. No dressing is required after the operation, beyond a piece of dry absorbent or salicylic cotton-wool laid on the wound, which will generally heal by the first intention. When these tumours occur upon the scalp, a large number may be removed at one sitting ; as, however, there is always some danger of erysipelas following operations in this situation, it is only prudent to select a favourable season of the year, and not to operate if the health be out of order. Erysipelas is the only danger to be apprehended : it is especially apt to occur in elderly people of a stout make and florid complexion. When seated about the face, back, trunk, or limbs, they usually require to be dissected out, being thin and more closely incorporated with the skin ; and often, in consequence of former inflammation, adherent to the subjacent parts. In doing this, care should be taken that the whole of the cyst-wall is extirpated ; the wound, which should be dressed lightly, speedily heals. If, however, any portion of the wall be left, it should be freely rubbed with nitrate of silver, lest a troublesome fistula remain. When the tumours are situated between the shoulders or on the back, and the patient is unwilling to submit to an operation, I have sometimes easily and successfully removed them by opening up with a probe the small black orifice, which will always be found leading into them, squeezing out the contents of the cyst, and then pushing in two or three silk threads,

which, acting like a seton, have excited the requisite amount of inflammation to bring about a closure of the cyst.

In some cases, in which, from the constitutional condition of the patient, or from prejudice on his part, the use of the knife is objectionable, these cysts may be removed by rubbing the skin in a linear manner with potassa fusa or fuming nitric acid. When the slough so formed separates, the cyst comes away with it or may be squeezed out.

The horns and malignant ulcers that result from these growths, may require excision. If, however, the ulceration be connected with the cranium by its base, or be very extensive, as in the case depicted (Fig. 363), it will be safer to treat it by the application of the chloride of zinc, or by occasionally touching it with potassa fusa.

(β.) **Mucous Cysts** arise in mucous membranes in the same way as atheromatous cysts in the skin. Their walls are usually thin, and, as a consequence, they seldom reach any great size. Their contents usually consist of a turbid viscid fluid and cholesterine is sometimes present. They are most commonly met with in the mouth, and occasionally in the tongue. They form one variety of ranula; and the so-called dropsy of the antrum, is in most cases a mucous cyst developed within the cavity. They are also met with in the labia, arising from the glands of Bartholini, and Cowper's glands in the male are said occasionally to undergo a similar change. They are best treated by excising a piece of the wall and inserting a few threads of silk into the cavity.

(γ.) **Cysts arising from the dilatation of the ducts of glands** are less common. They are met with in the mamma from obstruction of the lacteal ducts, in the mouth as ranula from obstruction of Wharton's duct, and in the testicle, forming the so-called encysted hydrocele or spermatocele. Cysts of similar origin are also met with in the liver and kidney. The consideration of the symptoms and treatment of these cysts must be deferred to the chapters on the diseases of the organs in which they occur.

II. Cysts of New Formation.—Cysts of new formation may be divided into (*a*) Simple or serous cysts; (*b*) Hæmatoma or blood cyst; (*c*) Cystic tumours, compound and proliferous cysts; (*d*) Cysts in tumours.

(*a*.) **Simple or Serous Cysts** may occur in any part of the body. They are composed of a thin wall lined with a flat endothelium, like that of a serous or synovial membrane. Their contents are a slightly viscid serous fluid. They are supposed to arise from effusion of fluid in the spaces of the areolar tissue; by the pressure of the fluid the surrounding fibres are pressed together and thus form the membranous wall of the cyst, which subsequently becomes thickened by new growth of fibrous tissue.

False or Accidental Bursæ arise in this way over any bony prominence which is exposed to pressure and friction, in fact there is some reason to believe that all bursæ are thus formed. Whether this be the case or not, false bursæ when once formed are liable to the same diseases as those that are usually assumed to be of normal development. The most common and troublesome false bursa is that formed over the projecting head of the first metatarsal bone which forms the condition known as a "*bunion*."

It is probable that many of the tumours classed as "ganglia" are formed in the same way, especially those on the back of the hand, as the extensor tendons in that region do not possess a sheath sufficiently definite to allow of a hernial protrusion from it.

The serous cysts met with in the neck do not belong to this class. They are either congenital or formed by dilatation of pre-existing spaces as the bursæ about the hyoid bone or larynx.

(*b.*) **Hæmatoma or Blood-Cyst.**—Under this term have been included four entirely different conditions.

(1.) The *true blood-cyst.* This is a thin walled cyst containing pure blood; if its contents are withdrawn by puncture it rapidly fills again, and cases have been recorded in which death from hæmorrhage has followed incisions made into them. They are most common about the neck, in close connexion with the sheaths of the vessels, or the parotid region; but they have been met with elsewhere. Their origin is very doubtful. Some, from their multilocular form and direct communication with the veins are supposed to have originated in nævi. In others, the cyst is single, and has no connexion with any distinct vessel; the blood seems in these to be furnished by an extremely vascular cyst-wall, as in a case recorded by Gay. The origin of these is very doubtful. These sanguineous cysts may sometimes resemble in general appearance encephaloid disease. A case of this kind was sent to me by Henry Bennet—a tumour of about the size of an orange, of nodulated appearance, existing in the leg of a woman below the knee, where it had been gradually increasing in size for about a couple of years. So close was the resemblance to malignant disease presented by the tumour, that the limb had been condemned for amputation by some Surgeons who had previously seen the case; as, however, the growth, on examination, proved to be a sanguineous cyst, as its walls were thin and adherent, and as it extended too deeply into the ham to admit of ready removal, I reduced it by successive tappings, and then, laying it open, allowed it to granulate from the bottom. When practicable, however, the cyst should always be dissected out.

(2.) Many cases have been described as sanguiferous or blood-cysts, which are in reality *serous cysts into which an accidental hæmorrhage has taken place.* In these, unless the hæmorrhage be very recent, the blood has undergone changes in colour from disintegration of the corpuscles. In some cases it is treacly from absorption of a part of the serum.

(3.) The term hæmatoma is more commonly applied to *cysts which have their origin in an extravasation of blood.* The changes that occur in extravasated blood have been already described (p. 296). In some cases, as is there pointed out, absorption fails to take place. The extravasated blood distends the spaces of the areolar tissue, or fills a cavity formed by subcutaneous laceration. A deposit of fibrin first takes place, and subsequently, in consequence of the irritation caused by the tension of the fluid, an ill-defined capsule of fibrous tissue is formed round the extravasation. The contained blood becomes altered in colour from disintegration of the corpuscles, and finally the contents assume the appearance of more or less darkly-tinged serous fluid. The hæmatoma of the ear so frequently met with as the result of violence during the game of football, when played according to the Rugby rules, is a cyst of this kind. Similar cysts are not uncommonly met with in the ear of lunatics, and in these cases the cause is not so evident. I have seen a large hæmatoma on each ear of a lunatic. The contents consisted of semi-solid coagulum.

Similar cysts are occasionally found in the arachnoid as a result of hæmorrhage into that cavity. The coagulated blood in the course of time becomes completely discoloured, and forms a thin membrane-like layer of tissue which

encloses a cavity containing a small quantity of serous fluid. There are excellent specimens of this condition in University College Museum.

(4.) In many cases which have been lately recorded, it has been found that tumours which were described clinically as blood-cysts were in reality *soft sarcomata*, the structure of which had been broken down by hæmorrhage. (See Sarcomatous Blood-cysts.)

(*c.*) **Cystic Tumours.**—These are tumours in which the development of cysts is an essential of their growth, and not merely an accidental complication. To this class belong the *compound* or *multilocular cysts* met with in the ovary, the mamma, and the testicle. In many cystic tumours solid growths project from the walls into the cavities, and from this they have received the name of *proliferous cysts ;* the growths are spoken of as *intracystic growths.* Multilocular cysts, as met with in the ovary, form the best example of this form of tumour. These cysts are composed of a fibrous wall and an inner lining of columnar epithelium. Immediately beneath the epithelium is a layer of embryonic tissue, from which spring the intracystic growths. These assume the form of branched papillæ projecting into the cavity of the cyst ; they are covered by columnar epithelium. Wilson Fox has shown that secondary cysts may be formed by the adhesion of adjoining masses of this papillary growth, thus forming small closed spaces or daughter-cysts, which become gradually distended by secretion. In some cases the reverse process takes place, and instead of the number of cysts increasing by the formation of daughter cysts, they become diminished by coalescence. Unilocular ovarian cysts are supposed to be often formed in this way. The contents of these cysts vary from a liquid, as thin as ordinary blood-serum, to a viscid fluid. It is sometimes coloured from the admixture of altered blood. Chemically it is found to contain met-albumin and par-albumin, and sometimes mucin, from which it is assumed that the fluid is a true secretion, in the formation of which the epithelial lining is concerned.

In the proliferous cysts of the mamma the intracystic growths assume a lobulated or cauliflower-like form, and in structure are found rudely to resemble the normal structure of the mamma. These growths may, according to Paget, cause by their increase in size the gradual absorption of the more fluid contents, until, at last, their development is arrested by the cyst-wall. The tumour would then merely resemble an ordinary adenoma of the mamma surrounded by a distinct capsule.

The cystic tumours of the ovary, mamma, and testes, will be more fully described with the diseases of those organs.

(*d.*) **Cysts in Tumours** form, not as an essential part of the growth, but as an accidental complication. They may arise from softening of portions of the growth, or from hæmorrhage into its structure. As a rule they are not surrounded by a distinct wall, but in some simple tumours they seem to increase by transudation of serum into the cavity, and thus the surrounding structure may be compressed so as to resemble a limiting membrane. Cartilaginous tumours occasionally become cystic from mucous softening of the matrix.

Cysts in tumours will be more fully described with the growths in which they occur.

III. Congenital Cysts may be divided into four classes. (*a.*) Those resulting from inclusion of a portion of the epiblast within the mesoblast during

development: (*b.*) Those arising from imperfectly obliterated temporary fœtal structures: (*c.*) Cysts formed by the inclusion of a blighted ovum within the developing body of the fœtus: (*d.*) Cysts of doubtful origin.

(*a.*) **Cysts arising from inclusion of a portion of the Epiblast. Dermoid cysts.**—It will be remembered that in the very earliest stages of development the germinal membrane or blastoderm divides into three layers; from the most superficial of these, or epiblast, is developed the cuticular covering of the body, with the hairs and glands of the skin and the central nervous system; from the deepest layer, or hypoblast, arise the epithelial lining of the air-passages and of the alimentary canal and the epithelium of the glands connected with it, while the rest of the body is developed from the middle layer or meso-

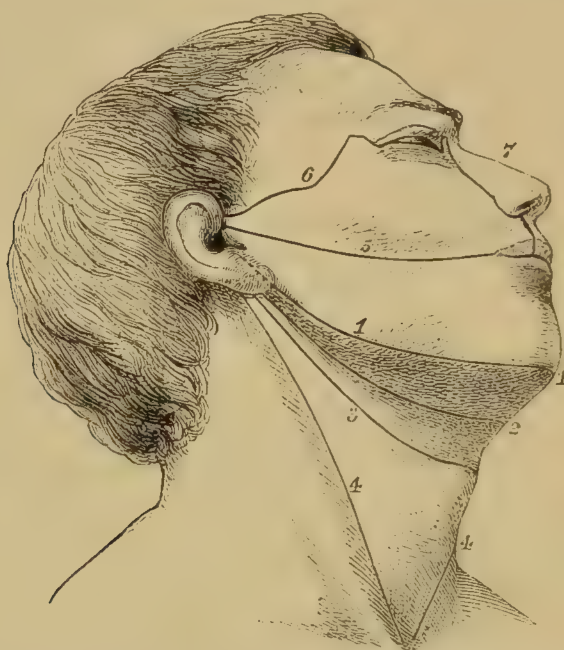


Fig. 365.—Head and neck of an adult, with diagrammatic lines, representing the situation and direction of the branchial clefts. 1, 2, 3, 4, first, second, third, and fourth clefts; 5, inter-maxillary cleft; 6, Fronto-orbital fissure; 7, naso-maxillary fissure.

blast. The blastoderm is at first flat, but in the process of development it becomes folded on itself, and thus encloses the abdominal cavity; the mouth and neck are developed from lateral processes, the branchial arches, which curve downwards till they meet in the middle line, and between these branchial arches are fissures, the branchial clefts. The lateral parts of the face are developed in the same way, while the nose and middle parts above the mouth arise from a descending process proceeding from the frontal region. By the coalescence of all these the face and throat are formed. It is easily to be understood how in this process a portion of the epiblast may become included and remain imbedded in the tissues belonging to the deeper layer. Should this happen, a closed cyst will be found lined internally with the structures proper to the skin, and yet entirely unconnected with it. These have received the name of *dermoid cysts.* They are met with most commonly in the subcutaneous tissue in situations in which their position can be explained by the process of inclusion above described. The accompanying diagram, from a paper by Cusset, well illustrates

the lines in the face which correspond to the branchial clefts, and to the meeting of the various processes from which the face is developed in the fœtus. It is in these lines that dermoid cysts are most commonly met with. They are most often found at the upper and outer angle of the orbit. Here there is often an indentation in the bone corresponding to the cyst, and in some cases the bone may be wanting, the tumour being in direct contact with the membranes of the brain, a fact which it is important to remember in attempting their removal. They have also been met with at the lateral aspect of the root of the nose; under the tongue in the floor of the mouth; on both sides of the hyoid bone, and in the line of the anterior border of the sterno-mastoid. In other parts of the subcutaneous tissue they are very rare. They have occasionally been met with on the meninges of the brain.

Dermoid cysts are also met with in situations in which their origin is not so easily explained. Thus they occur with some degree of frequency in the ovary or its immediate neighbourhood and more rarely in the testicle.

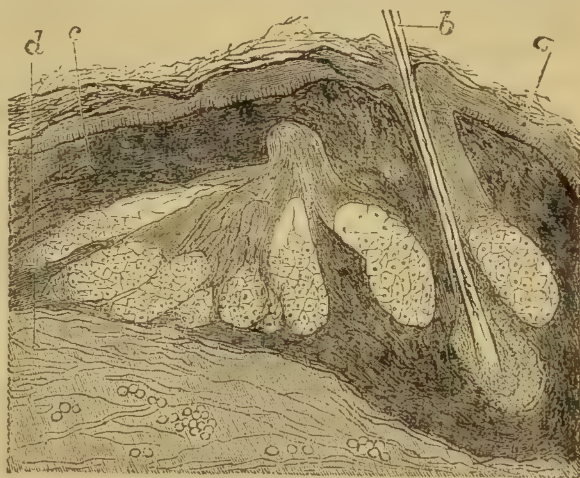


Fig. 366.—Wall of Dermoid cyst (40 diam.).
a. Epidermis.
b. Hair-follicle.
c. Sebaceous gland.
d. Surrounding connective tissue with small masses of fat.

The walls of the superficial dermoid cysts present all the structures of true skin; cuticle, cutis vera, papillæ, sweat-glands, sebaceous follicles, hair-follicles, and hair. (Fig. 366). Their contents are usually rather thinner than those of the ordinary atheromatous cyst, though closely resembling them in appearance. Often a small ball of coiled-up hair is found inside the cavity. The contents are the accumulated secretions of the glands in the cyst-wall mixed with desquamated epithelium.

The ovarian dermoid cysts may closely resemble those of the subcutaneous tissue, but may attain to a much greater size. In some cases they have been found to contain teeth, and have then received the name of *dentigerous cysts.* In some cases the teeth are set in a piece of bone resembling the alveolar bone of a jaw.

(*b.*) **Congenital Cysts arising in Imperfectly Obliterated Fœtal Structures.**—To this class may be referred the cysts of the spermatic cord which arise from the distension of a portion of the processus vaginalis testis which has remained unobliterated, although cut off from the cavity of the peritoneum above and the tunica vaginalis below.

Some tumours of the testicle and some growths arising in the neighbourhood of the kidney which contained large cysts lined with columnar epithelium are supposed to arise from the unobliterated remains of the Wolffian body; and the parovarian cysts arising in the broad ligament of the uterus have the same origin.

(*c.*) **Cysts formed by the Inclusion of a Blighted Ovum in the developing Body of a Fœtus.**—Tumours containing various structures

such as bone, teeth, cartilage, &c., have been ascribed to this cause, but the evidence of their origin is far from certain. They are most common in the abdomen, especially about the ovaries, mesentery, and omentum; they have also been observed in connection with the testes, having probably descended into the scrotum with this gland. A very remarkable case of this kind once occurred at University College Hospital under the care of Marshall. They have also been found in the lung, but never, I believe, in connection with the extremities.

(*d.*) **Congenital Cysts of Doubtful Origin.**—A class of congenital cysts has been described under the name of *cystic hygroma*, the origin of which is uncertain. They are most commonly met with in the neck, usually in front, but are also found in the subcutaneous tissue in other parts of the body. They form also one variety of the congenital sacral tumours. They are composed of a number of thin-walled cysts, sometimes completely closed and sometimes communicating with each other; the separate cysts are held together by areolar tissue, in some cases containing fat. The contents are clear and serous. They attain often a great size in the neck and sacral region, but in other situations they are seldom very large. The walls of the cysts are lined in some cases with an endothelium like that of the lymphatics, and these have been supposed to be lymphatic nævi; that is to say, multilocular cysts formed by dilatation of the lymphatics. If their size permits of it, they can be removed; other modes of treatment have not proved successful.

(**5.**) **Parasitic Cysts.**—Cysts also occasionally come under the care of the Surgeon which owe their origin to the presence of a *parasite*. The most common of these is that known as the hydatid cyst. This is due to the presence of the scolex of the tænia echinococcus. The parasite in this stage of development is cystic in form. It never reaches its fully developed state in the human body; the tænia (or tapeworm), of which it is the scolex, being known to exist only in the dog and wolf. In the human body it is commonly found to present the following appearances. Most externally is a cyst-wall composed of the tissues of the part, altered by the pressure of the cyst, and indurated by fibroid growth. Within this is the wall of the cyst, belonging to the parasite. This is often half an inch or more in thickness, and is composed of a semi-transparent, elastic substance, not unlike the white of a hard-boiled plover's egg. It is beautifully laminated to the naked eye, and a still finer lamination is seen under the microscope. This cyst is spoken of as the *acephalocyst.* Sometimes the cyst is single, but frequently numerous secondary or daughter cysts are found in its interior. The contents of the cyst consist of a clear fluid of very low specific gravity, usually not over 1007, and containing either no albumen, or only the faintest possible trace. The characteristic tænia-heads, as they are called, are found either adherent to the cyst-wall, or free in the fluid. The head is small and rounded, about $\frac{1}{100}$ in. in diameter, and provided with four suckers and a ring of hooklets. Frequently no perfect echinococci can be found, but the hooklets, being indestructible, can usually be detected. Hydatid cysts are found in almost all parts of the body. They are most common in the liver, and occur in other organs in the following order of frequency:—lungs, muscles and subcutaneous tissue, kidneys, pelvis, nervous centres, bones, and heart. They are in rare cases found in the eye. The cyst-wall may undergo calcification, and the tumour cease to trouble the patient. Occasionally suppuration may occur round the cyst, and the whole

may be discharged. A few years ago I opened a very large abscess in the adductor region of a young woman's thigh, and gave exit to nearly a pint of pus, in which dozens of small hydatid cysts about the size of gooseberries were floating. The diagnosis of these cysts when seated in the subcutaneous or muscular tissues cannot be made with certainty, except by withdrawing some of the fluid with the aspirator, and submitting it to microscopic and chemical examination. If it be of low specific gravity and free from albumen, it is almost certain to have come from a true hydatid cyst. The *Treatment* of these cysts, when practicable, is the complete removal of the parasite. A few years ago I successfully removed a hydatid cyst of the size of a fist from the muscles at the back of the neck of a young man. In internal organs, tapping, aspiration, simple acupuncture and galvanopuncture have all been successful. Aspiration and acupuncture, however, seldom succeed. The only efficient treatment is to open the cyst and to insert a drainage-tube. This should be done with antiseptic precautions, otherwise septic inflammation is very apt to follow the operation, and may terminate fatally.

II.—TUMOURS COMPOSED OF ONE OF THE MODIFICATIONS OF FULLY DEVELOPED CONNECTIVE TISSUE.

The structures included under the term "connective tissue and its modifications," are fat, fibrous and areolar tissue, cartilage, bone, and mucous tissue. The tumours composed of any of these tissues in a state of perfect development are almost uniformly benignant. Occasionally enchondroma assumes a malignant form, but it will then be usually found that, instead of being covered by a firm fibrous membrane at the margin of the growth, there is a zone of embryonic tissue which is infiltrating the surrounding parts on one side and becoming developed into cartilage on the other. It is from this tissue, probably, that the system becomes infected, and not from the fully developed cartilage. In the same way, tumours which to the naked eye seemed to be composed of bone may assume all the characters of malignancy ; but on microscopic examination it will be found that these tumours do not grow as normal bone does, either from a fibrous membrane (periosteum) or from cartilage, but are in fact ossifying sarcomata. These will be described amongst the sarcomata. Again, there is no absolute boundary between sarcoma and fibroma. Many tumours composed almost entirely of spindle-cells contain a large proportion of fibrous tissue between the cells. If the fibres very much exceed the cells, the growth would be called a fibroma ; if the reverse a sarcoma ; and one between the two is often spoken of as a fibro-sarcoma. As a broad rule, it may be said that the benignancy of the growth will be in proportion to the perfection of the development of the tissue of which it is composed.

a. **Fatty Tumour or Lipoma.**—These tumours constitute an important class of surgical diseases, as they occur very extensively in almost every part of the body, and at all ages, though they are most commonly met with about the earlier periods of middle life. In the majority of cases they appear to originate without any evident cause ; in other instances they can be distinctly traced to pressure or to some local irritation, as to that of braces or shoulder-straps over the back and shoulders. In one case I have known the disease to be hereditarily transmitted to the members of three generations of a family.

Fatty accumulations take place under two forms, one diffused, the other circumscribed ; it is the latter variety only that is termed the **Adipose or**

Fatty Tumour. The diffused form of fatty deposition occurs in masses about the chin or nates without constituting a disease, though it may occasion much disfigurement. This form was described by Brodie under the name of "fatty outgrowth."

Fatty tumours may form in all parts of the body as soft, indolent, inelastic doughy swellings, sometimes giving rise on manipulation to a feeling closely resembling fluctuation. They grow very slowly, and are usually oval or round in form, but frequently lobulated to a most extraordinary degree. They occur most frequently in the subcutaneous fat about the neck and shoulders, and are occasionally met with between muscles, in the neighbourhood of joints and of serous membranes and of mucous canals, sometimes in very unusual situations, where such growths would scarcely be looked for. Thus I removed some time since a lipoma three inches in length, and as thick as the thumb, from under the annular ligament and the palmar fascia of a young woman. A very curious circumstance connected with these tumours is that they occasionally shift their seat, slowly gliding for some distance from the original spot on which they grew; thus, Paget relates cases in which fatty tumours shifted their position from the groin to the perinæum or the thigh. I have known one to descend from the shoulder to the breast. When growing superficially, they sometimes become pedunculated. They may attain a large size, but occasion inconvenience only by their pressure or bulk; sometimes they appear in great numbers, upwards of 250 tumours of various sizes having been found in the same individual; and C. v. Lutzau records a case in which they reached the extraordinary number of 2,436. They rarely ulcerate or inflame, nor do they undergo any ulterior changes of structure.

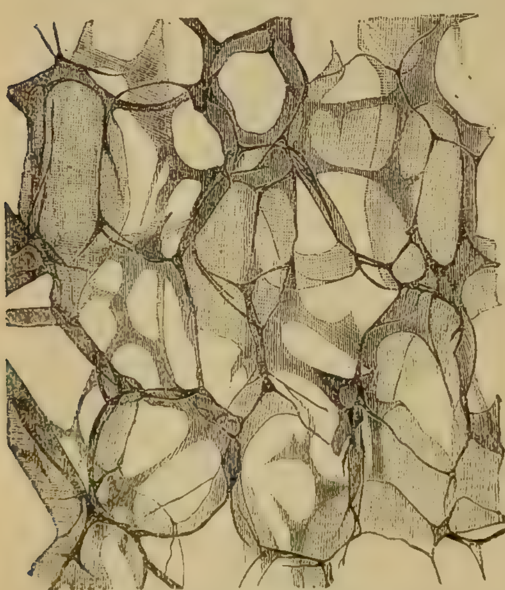


Fig. 367.—Fatty Tumour (188 diam.) Some of the cells show crystals of fatty acids.

The typical **lipoma** is simply a mass of fat, usually differing in structure in no way from the ordinary subcutaneous adipose tissue (Fig. 367), but it is not uncommon to find crystalline deposits of the fatty acids in the cells. It is inclosed in a fine thin capsule of areolar tissue, having small vessels ramifying over its surface. This capsule is adherent to the surrounding structures, but loosely connected with the tumour itself; so that, in operating for the removal of these growths, it is important thoroughly to open the capsule before attempting to remove the tumour.

These tumours, which present the least possible deviation from the normal structure of the parts in which they grow, are derived from the connective tissue by an increased development of fat. They present occasionally some minor varieties of structure. Thus the fibrous tissue may be in excess, giving rise to the so-called "fibrous lipoma," or the tumour may be permeated by numerous dilated vessels, as in the "erectile lipoma" or "nævo-lipoma." These

conditions are, however, rare. Occasionally mucous tissue may be found intermixed with the adipose, forming the "myxo-lipoma." This will be again mentioned under myxoma.

The **diagnosis** of a fatty tumour is usually easy. It is not adherent to the muscles over which it is lying. This can easily be ascertained by making the patient throw the muscles into contraction, when the mobility of the tumour will be found to remain unaltered. It is more easily confounded with a soft sarcoma or a chronic abscess. The sarcomata usually spring from or early become adherent to the deep fascia or muscles. On pinching up the skin over a fatty tumour, it will be found to dimple in several places, although it is quite freely moveable over the growth. This sign is wanting in a sarcoma. A fatty tumour is distinguished from a cyst or chronic abscess by pressing on its edge, when the solid tumour will be felt to roll away from under the finger; in a collection of fluid, the finger sinks through the edge without the sensation of anything slipping away from beneath it. When the tumour is lobulated, there can be little doubt as to its nature. If any doubt should remain, it may be punctured with a grooved needle or a fine trochar.

In the *Treatment* of fatty tumours little can be done except extirpation with the knife, by which the patient is speedily and effectually rid of the disease. The tumour, being encapsuled and but loosely adherent to adjacent parts, readily turns out if the capsule be freely opened. The opening of the capsule is recognised by the appearance of the smooth shining surface of the tumour in the bottom of the wound. Great care must be taken that none of the lobules frequently found in these tumours are left behind, as they would certainly serve as starting points for new growths. The wound often heals by first intention. It is true that we have the sanction of Sir B. Brodie's high authority for the administration of the liquor potassæ in some cases, under which treatment this eminent Surgeon states that fatty tumours have occasionally disappeared.

b. **Fibroma: Fibrous or Fibroid Tumours, Desmoid Tumours, Areolar and Fibro-cellular Tumours.**—In the healthy body, fibrous tissue is found either dense and firm as in tendons, or loose and filamentous as in areolar tissue, and between these two extremes every variety of density is observed. In healthy areolar tissue two kinds of fibres are almost invariably present: the white fibrous and the yellow elastic tissue. In tumours composed of fibrous tissue, similar variations in density are found. Thus we have fibrous tumours as dense in structure as ligaments, and others as loose as areolar tissue, but in all it is extremely uncommon to find any yellow elastic fibres. Fibrous tissue enters very largely into the composition of many tumours besides the true fibromata. Thus the stroma of most cancers is composed of fibrous tissue, the intercellular substance of a sarcoma may be abundantly fibrous, and in a lipoma the lobules of fat are bound together by areolar tissue. The term fibroma is, however, applied only to those tumours in which fibrous or areolar tissue forms by far the most abundant constituent, and in which the cells are not of an epithelial type and are not arranged in definite groups. As before stated, no sharp line can be drawn between fibroma and sarcoma, and the term fibro-sarcoma is frequently applied to those tumours in the border-land between the two. Fibromata may be divided into two chief classes:—1. Soft fibromata, areolar tumours, and fibro-cellular tumours; 2. Firm fibromata, desmoid tumours, and fibroid tumours.

1. **Soft Fibromata.**—These may be diffused or circumscribed; in some cases they are distinctly encapsuled. The diffused variety or *areolar tumours* are little more than a simple hyperplasia of the subcutaneous or submucous areolar tissue. They are represented by pendulous fleshy growths, forming large tumours, commonly called **Wens**, which may occur on any part of the surface. They are smooth, pedunculated, firm but somewhat doughy, non-elastic, pendulous, and movable, slowly increasing without pain often to a very great size. They are thinly covered with skin, bearing abundant papillæ, and sometimes enlarged sweat-glands and hair-follicles. Large vessels may ramify on the surface, and occasionally the skin is pigmented. They are sometimes congenital. In the disease known as **molluscum fibrosum** these tumours form pedunculated masses or rolls, hanging from the skin of the buttocks, thighs, and other parts of the body, and may attain such a size as seriously to inconvenience the patient by their weight. These masses are composed merely of connective tissue, sometimes dry and tough, sometimes œdematous. They contain large blood-vessels, frequently of such size as to render removal of the growth a most hazardous operation. A somewhat similar condition is seen in the disease known as **Elephantiasis Arabum**, in which the skin and areolar tissue of the affected part undergoes an enormous hypertrophy; but the new growth in this case is not pedunculated, and is moreover distinctly connected with repeated attacks of inflammation of the lymphatic vessels of the part. It is in warm climates and in the Hindoo and negro races that this disease attains its greatest development. It attacks chiefly the genitals, the hypertrophy affecting the skin and areolar tissue of the scrotum and penis in the male, or depending from the labia in the female, and forming an enormous mass fifty, seventy, or even a hundred pounds in weight. The remarkable enlargement of the leg occurring in the Mauritius and some parts of the West Indies, and hence termed Barbadoes leg, is an affection of this kind. The skin in these cases becomes dark-coloured, rough, and scaly, like that of an elephant, whence the name of the disease. It should perhaps be classed rather with diseases of the lymphatic system than with tumours properly so called.

In the *Treatment* of these affections, pressure and iodine applications may be tried in the earlier stages, with the view, if possible, of checking their growth; at a later period they must, if large, be removed by operation, though this procedure is at times an extremely severe one, owing to their great size.

Tumours of the *circumscribed variety*, described by Paget as fibro-cellular, are not of common occurrence; and when met with they are most frequently found in the scrotum, the labium, the deep muscular interspaces of the thigh or axilla, and on the scalp, in which situation they may form large masses, attaining sometimes to a weight of many pounds. When seated in the subcutaneous tissue these tumours may become pedunculated, as in the accompanying figure (368), which represents a tumour of this kind which I removed from the side of a woman. I have removed one weighing nearly four pounds from the axilla of a woman, where it lay between the serratus magnus and the ribs, forming a tumour of great size. When they occur about the scrotum and labium, these tumours must not be confounded with elephantiasis of these parts, from which they may be distinguished by being limited and circumscribed masses, and not mere outgrowths. Paget observes that, when occurring

about the genital organs, they are found in young women and in old men. They occur only in adults who otherwise are in good health, and grow quickly, forming soft, elastic, rounded, and smooth tumours; they are not attended by any pain. After removal they are found to possess a thin capsule, to be of a yellowish colour, and to contain a large quantity of infiltrated serous fluid, which may be squeezed out abundantly, and coagulates on standing. This fluid may be so abundant as to give rise to distinct fluctuation. Thus, a few years ago, I removed a soft fibroma from amongst the short muscles of the thumb, which had been previously treated unsuccessfully by puncture, under the impression that it was cystic in nature.

Fig. 368.—Pendulous Fibro-cellular Tumour.

Under the microscope these tumours display a beautifully delicate network of white fibrous tissue, arranged in undulating filaments and fibrous bands, in the midst of which stellate, spindle-shaped, oval or round cells are found. These cells are similar to those normally found in fully developed or growing fibrous tissue. They vary in abundance, but never exceed the fibrous tissue in amount. The cells are rendered more apparent by the addition of acetic acid. These tumours sometimes appear to grow rapidly, when, in reality, the increase in size is due to a rapid increase of the fluid, and not to a new deposit of a solid character in the tumour. As these tumours are perfectly innocent, no hesitation need be entertained about their removal.

2. **Firm Fibromata—Fibroid or Desmoid Tumours.**—These tumours are met with in various situations, the most common of which are the bones and periosteum, the mamma, the subcutaneous connective tissue, and in connection with nerves. In the uterus, " fibroid " tumours are exceedingly common, but in this situation they contain not only fibrous tissue, but also a variable amount of non-striated muscular fibre. Amongst the best known examples of firm fibromata may be enumerated, the simple or fibrous epulis, the fibrous tumours of the antrum or lower jaw, the fibrous polypus of the nose, the ordinary or false neuroma, and the painful subcutaneous tubercle. Fibrous tumours are seen also in the neck, especially in the parotid region. In shape these tumours are irregularly oval or rounded; they are smooth, painless, and, except when growing from bone, freely movable; they increase slowly, but may attain an enormous size, equal to that of a cocoa-nut or water-melon. Liston removed one from the neck, which is at present in the Museum of the College of Surgeons, that weighed twelve pounds; they have, however, been found weighing as much as seventy pounds. They are almost invariably single; they are excessively firm and hard, but yield slightly on pressure, in this differing from bony tumours. When cut into, they present a white glistening fibrous structure, often showing, to the naked eye, bundles of interlacing fibres. Sometimes the fibres show a concentric arrangement (Fig. 369); an appearance which, according to Billroth, is due to the fibrous formation taking place around nerves and vessels. On microscopic

examination, pure fibromata are found to be composed of interlacing bundles of white fibrous tissue, scattered amongst which are cells, few in number, and spindle-shaped, stellate, or oval in form (Fig. 370). These are often rendered apparent only by the addition of acetic acid. In most cases the vessels are not abundant, but frequently these tumours can be shown by injection to be very vascular. Sometimes coarse cavernous spaces may be found. The vessels are intimately adherent to the fibrous structure of the tumour, and consequently, being unable to contract or retract, they pour out enormous quantities of blood if opened by wound or ulceration. This is especially the case in those fibrous tumours which grow from the bones of the head or face, as in the fibrous polypi growing from the body of the sphenoid

Figs. 369, 370.—Firm fibromata (188 diam.). Fig. 369, from a small Fibroma of the forehead, shows the circular arrangement of the fibres. Fig. 370, from a naso-pharyngeal polypus, resembles ordinary fibrous tissue.

bone. Hæmorrhage is moreover often a marked symptom of fibroid tumours of the uterus.

Fibromata form most commonly about middle life, and may remain stationary for years, and this is the condition in which they are often presented to the Surgeon. They may, however, suffer various changes. They may undergo disintegration, becoming œdematous, and softening in the centre, or at various points of the circumference ; they then break down into a semi-fluid mass, the integuments covering them inflame and slough, and unhealthy pus, mixed with disorganized portions of the tumour, is poured out, leaving a large and sloughy chasm, from which fungating growths may sprout, readily bleeding on the slightest touch, and giving the sore a malignant appearance ; the patient eventually falling into a cachectic condition, and becoming exhausted by the hæmorrhage and discharge. In other cases these tumours may calcify, or more rarely undergo true ossification. In rare cases the central parts of these tumours may undergo a process of softening, so as to form large cysts containing fluids of various shades of colour. Paget relates the case of a very large cyst of this kind formed by the hollowing out of a fibroid tumour of the uterus, which was tapped by mistake for ovarian dropsy.

Some of the forms of fibroma require further mention here, though they will be again mentioned under the diseases of the organs in which they occur.

Fibromata of Bone.—These may grow from the centre of the bone, as is not unfrequently seen in the lower jaw, or from beneath the periosteum. The diagnosis between these latter and the firmer varieties of sarcoma can be made only after removal. Virchow lays great stress upon the fact that periosteal fibromata do not penetrate into the structure of the bone, or show any tendency to infiltrate the surrounding soft parts, while the reverse is the case with the sarcomata.

Fibromata of Nerves.—These are commonly spoken of as neuromata, although this term would be more properly limited to those tumours in which newly-formed nerve-filaments are found. They form rounded tumours, over which the fibres of the nerve are stretched ; they are frequently multiple, sometimes extremely numerous, very hard and dense, and almost invariably painless, and not affecting the function of the nerve upon which they grow. They are more movable in a direction transverse to the course of the nerve upon which they are seated than in any other, when the limb is put in such a position as to tighten the nerve ; a symptom which is of some importance in their diagnosis.

Fibromata of Glands are rare, being almost confined to the mamma.

Painful Subcutaneous Tubercle is a peculiar form of fibroma, found beneath the skin, usually of one of the extremities, but very rarely of the trunk. It is seldom more than half an inch in diameter, and is so small as scarcely to cause a prominence on the surface, yet it gives rise to pain of the most intense and agonizing character, usually called forth by some slight touch or pressure, and then lasting perhaps for an hour or more. These tumours are not neuromata ; at any rate, no connection has as yet been traced between them and nerve-filaments. They are by far more frequent in females than in males.

Fibroid Tumour of the Uterus.—These tumours, as before stated, are not pure fibromata. In addition to the fibrous tissue, such as is found in pure fibromata, they present numerous long spindle-shaped cells, which were shown by Virchow to be involuntary muscular fibre cells, and consequently these tumours are classed by many writers under "myomata" or "myo-fibromata." In the tumours of old women these muscle-cells frequently undergo atrophy, and the tumour then presents the appearance of a pure fibroma. Fibroid tumours of the uterus project either into the cavity of the organ, forming uterine polypi, or into the cavity of the pelvis. They are liable to softening and ulceration, accompanied by much hæmorrhage when they assume the polypoid form. Under any circumstances they frequently calcify, and occasionally, as above stated, soften, forming enormous cysts. Somewhat analogous tumours are found in the prostate gland in the male.

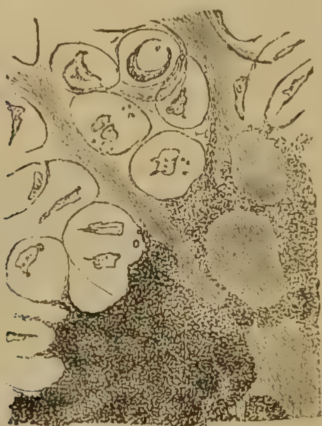
The *Treatment* of fibromata is in a great measure palliative ; but when they are so situated as to admit of removal, as in the neck, lower jaw, antrum, mamma, or subcutaneous tissue, they should always be extirpated.

Tumours closely resembling fibromata in naked eye appearance and consistence, have been known to recur after removal with much tendency to ulceration, sloughing, and hæmorrhage. They may even give rise to secondary deposits in internal organs. These tumours will always be found on microscopic examination to present the signs of one of the forms of sarcoma to be described hereafter. Pure fibromata are invariably benignant.

c. **Enchondroma — Chondroma — Cartilaginous Tumours.** — These

tumours form an exceedingly interesting group, being of comparatively frequent occurrence, and sometimes assuming a large size.

In structure, a chondroma closely resembles normal hyaline cartilage (Fig. 371). The cells vary much in size and shape. In the most typical form they are large ($\frac{1}{300}$ to $\frac{1}{800}$ inch), round, oval or polygonal in shape, contain a single large nucleus and nucleolus, and are sometimes inclosed in a capsule as in normal cartilage. Occasionally the cells are found to be irregular in shape and



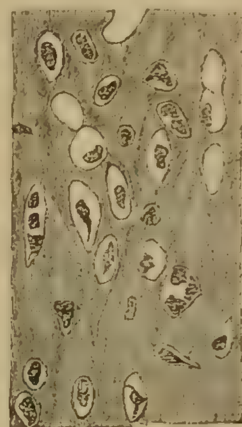


Fig. 371.—Enchondroma (188 diam.). From a small tumour near, but distinct from, an ossifying enchondroma of the femur, shows the variety in shape of the cells and capsules. At the lower part calcification is taking place involving first the matrix and then the cells. Fig. 372.—From an enchondroma of the finger; matrix faintly fibrillated.

branched, the processes of one cell communicating with those of another, as in a myxoma. This form resembles the cartilage normally found only in the cuttle-fish. The matrix may be hyaline, as in normal fœtal or articular cartilage, or contain a few fibres. It varies much in density, occasionally being so soft as to give the tumour a false sense of fluctuation. This softness is usually found in the more rapidly growing varieties. The tumour may consist of a single mass of cartilage, or may be composed of innumerable lobules. bound together by vascular bands of fibrous tissue. It is this vascularity that often forms the most striking difference between normal cartilage and enchondroma. Its surface may be covered by a distinct fibrous layer, sharply limiting it from the surrounding tissues, or the mass of cartilage may be surrounded by a vascular zone of embryonic tissue, sometimes composed of round, and sometimes of spindle-shaped cells, which may infiltrate and invade the surrounding structures. It is this variety, which is more properly classed as a chondro-sarcoma, that assumes the characters of malignancy. Enchondromata are liable to various secondary changes. Thus they may undergo true ossification. The ordinary pedunculated or spongy exostosis is usually found to be covered with a thick layer of cartilage, so that it might be spoken of as an ossifying chondroma. Calcification is a far more common change than true ossification (Fig. 371). Not unfrequently mucous softening takes place in the matrix. The cells in this condition float free in the fluid, and undergo degeneration, becoming filled with large globules of fat. This mucous softening may be so extensive as to give the once solid tumour the appearance of a thick-walled cyst. In a case of a very large enchondroma of the ribs under my care a few years ago, I was enabled to make the diagnosis by microscopic examination of a small quantity of such fluid, removed by means of the aspirator.

Cartilage may be found also mixed in one tumour with other structures. Thus the cartilaginous tumours of the parotid region are seldom, if ever, pure, but contain mingled together the structures of myxoma, adenoma, and enchondroma. Enchondroma and sarcoma are not infrequently found as constituents of the same tumour. Encephaloid cancer and enchondroma have also been found combined in the testis.

Cartilaginous tumours when composed of pure cartilage are always benign; when mixed with embryonic tissue, as in the chondro-sarcoma, they frequently run a malignant course. The simple chondroma occurs as a hard or slightly elastic tumour, ovoid or round in form, sometimes smooth on the surface but more often lobulated, and of small or moderate size, seldom exceeding that of an orange, and growing slowly without pain. The chondro-sarcoma grows rapidly, often attaining an enormous size in a few months, and giving rise to secondary growths in internal organs.

When cartilaginous tumours attain a large size and soften as above described, the skin covering them may become duskily inflamed, eventually slough, and form fistulous openings, through which a thin, jelly-like matter is discharged.

Locality.—Most frequently enchondroma occurs in connection with some bone. It is most frequent in the metacarpus and phalanges of the fingers

Fig. 373.—Large Enchondroma of Index Finger.

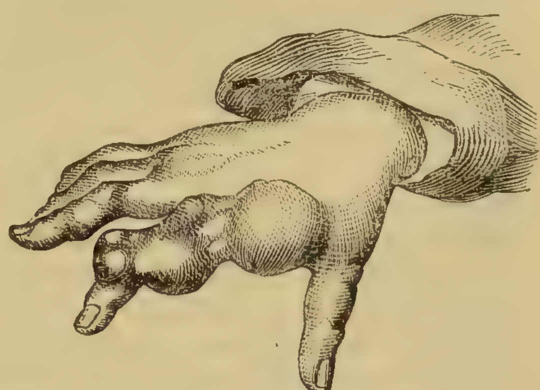


Fig. 374.—Ordinary Enchondromata of Finger.

(Figs. 373, 374). It is rare, in this situation, to find only one bone or phalanx affected: the tumours are almost invariably multiple. They form hard or elastic rounded knobs, seldom larger than a walnut or a pigeon's egg. Large chondromata are most commonly met with in or upon the head of the tibia or the condyles of the femur, forming in these situations rapidly increasing growths of considerable magnitude. Chondromata are found also on the ribs and bones of the pelvis, in the intermuscular spaces of the neck, thigh, and leg, in connection with the sheaths of tendons, and occasionally in glands; but in this last situation they are seldom, if ever, pure, being mixed with myxoma, adenoma, or sarcoma, and when in the testicle, occasionally with carcinoma. It is a curious fact, that chondromata never arise in connection with pre-existing cartilage. When connected with the bones, chondroma may spring from the periosteum, gradually enveloping, absorbing, and eventually destroying, the osseous structures, though at first not incorporated with them. It has then been distinguished as "perichondroma." This is its usual mode of origin when occurring in the femur or tibia; but when seated on the short bones,

especially on the metacarpus and phalanges, it commonly springs from the medullary canal, which becomes expanded by gradual absorption of the compact tissue, with a constant growth of new bone beneath the periosteum. Thus the tumour remains long covered by a thin shell of bone. Finally the growth perforates its bony covering at one side, and then advances more rapidly in that direction. These tumours occur in childhood or young adult life. They never assume a malignant form, nor do they ossify. Calcification is common, and mucous softening occasionally, but rarely, takes place in their interior, leading to ulceration of the skin.

The *Treatment* consists either in excision of the tumour, or in amputation of the affected part. Excision may be practised when the tumour is seated in the parotid region, or otherwise unconnected with bone. When forming part of the osseous structures, it cannot well be got rid of without the removal by amputation of the bone that it implicates. When it occurs in the hand, removal of the affected fingers and metacarpal bones, to an extent proportioned to the amount of the disease, will be required ; but it should be remembered that in this situation enchondromata are always perfectly innocent, and consequently the operation should not be performed if the finger be useful to the patient, unless he is willing to sacrifice an useful finger to get rid of an unsightly deformity.

In Fig. 36 may be seen the kind of hand left after operation in the case from which Fig. 373 was taken. If, in these circumstances, excision of the tumour only be attempted, it will be found that the whole mass cannot be removed, and that it rapidly grows again ; or that the wound formed by the operation remains fistulous and open.

Removal of a pure chondroma is followed by a permanent cure. The mixed cartilaginous tumours, as chondro-sarcoma or adeno-sarcoma, sometimes return after removal, both locally and in internal organs.

(*d*) **Osteoma. Exostosis. Bony Tumour.**—In order to render the review of the different varieties of tumour complete, it will be necessary briefly to mention the osteomata in this place, though their clinical characters will be more fully treated of in the chapter on the Diseases of Bones. In the first place, it is necessary accurately to distinguish mere calcification from the formation of true bone. The former is extremely common, the latter somewhat rare. Bone appears in tumours under four chief conditions ; 1st, as the result of the ossification of a fibroma; 2nd, of a sarcoma ; 3rd, of an enchondroma ; and 4th, as a special growth covered with a firm layer of periosteum. Bone has been described as occurring also in connection with carcinoma ; but this assertion has not been confirmed since the separation of cancers and sarcomas. Only the last two forms mentioned above are usually spoken of as bony tumours or exostoses. They differ essentially from each other in their seat and consistence, as well as in their mode of growth. Those developing from cartilage or spongy exostoses, are situated almost invariably in the immediate neighbourhood of an epiphysis, and rarely, if ever, start into growth after the twenty-fourth year ; those developing from a fibrous periosteal covering, ivory exostoses, are of extreme and remarkable density, and are usually seated on flat bones, such as those of the head, face, scapula, and pelvis. Both these growths closely resemble normal bone in structure, the spongy exostosis exactly agreeing with the cancellous tissue of the extremity of a long bone, and the ivory or hard exostosis corresponding to the petrous portion of the temporal,

the lower jaw, or the compact tissue of a long bone. Both forms are invariably non-malignant.

Spongy Exostoses, sometimes called pedunculated or cauliflower exostoses, from their shape, are most common at the upper end of the humerus and the lower end of the femur (Fig. 375A), and on the ungual phalanx of the great toe. If observed during the stage of growth, they are found to be covered by a perfectly developed hyaline cartilage, which apparently grows from the perichondrium covering it, and quickly undergoes ossification at its deep surface. If the tumour be observed when all growth has ceased, it will be found to be completely bony, being composed of a pedunculated mass of cancellous tissue, covered thinly by a layer of compact bone. The cancellous tissue of the tumour is continuous with that of the bone upon which it grows, the compact tissue of the shaft being absorbed beneath the base of the tumour. Sometimes these tumours are hereditary and multiple. They scarcely ever reach a great size, and probably cease to grow if they become completely ossified.

Fig. 375.—Pedunculated exostoses (natural size).
A. From femur of a boy.
B. From scapula of a child three years old.
a. Hyaline cartilage.
b. Layer of imperfect ossification.
c. Well-formed spongy bone.
d. Periosteum.
The drawing illustrates the different proportions which the various constituents of the tumour may bear to one another.

Ivory Exostoses.—These tumours form flat rounded elevations, usually seated about the bones of the skull or face. They are covered with a fibrous membrane and are of intense hardness. Occasionally they are multiple and grow to a considerable size, and when seated on the facial bones distort the features horribly, and at last after years of suffering possibly cause death by pressure on the brain.

(*e.*) **Myxoma. Mucous Tumour.**—These tumours are classed by some writers under sarcomata, as the tissue of which they are composed closely resembles the rudimentary fat of the fœtus. In the adult, the vitreous body of the eye is the only part in which mucous tissue is normally found. Many tumours formerly described as colloid cancer belong properly to this class. Myxomata usually form round, oval, or lobulated masses, distinctly surrounded by a loose capsule of connective tissue. They are tense, elastic, and gelatinous, frequently giving rise to a sense of fluctuation so distinct as to lead to their being mistaken for cysts. They are usually of slow growth. On section they are found to be of a delicate pink colour, sometimes stained by hæmorrhages, or they may present an uniform yellowish tint. The most marked peculiarity they present on section is in the fluid which flows from the cut surface. This is abundant, glairy, and tenacious, having the appearance of thick gum-water. On chemical examination it is found to contain mucus; microscopic examination shows (Fig. 376) in the purest forms of myxoma a beautiful network composed of large stellate or branched cells, the processes of which freely communicate with one another. These cells are embedded in an almost homogeneous intercellular substance, in which vessels can be clearly seen to ramify. It is seldom, however, that this structure is found so pure as this. In addition to the stellate cells, numerous small round cells (Fig. 377) are usually present, and the intercellular substance is in most cases traversed by delicate bundles of

fibrous tissue, sometimes containing yellow elastic fibres. The stellate cells may be smaller in some cases than in others. The peculiar feature of the growth is the mucous intercellular substance, and without this being present no tumour should be called a myxoma. Frequently, tissue agreeing in all respects with that of a pure myxoma is found mixed with that of sarcoma, enchondroma, or adenoma. These tumours are spoken of as myxo-sarcomata,

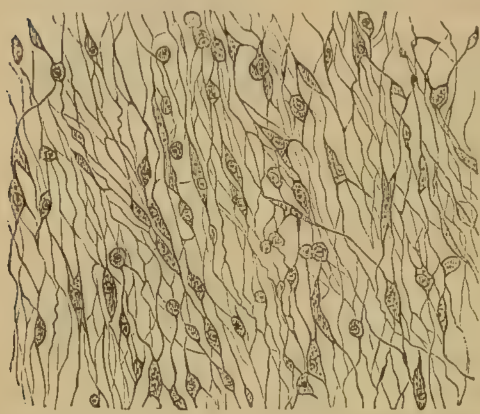


Fig. 376.—Myxoma, from a large tumour in the skin of the back (188 diam.). It will be noticed that even the round cells are connected with those which are more branched.

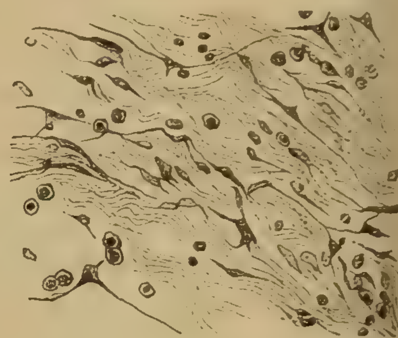


Fig. 377.—Mucous Polypus of Nose (188 diam.). The round cells vary in size and are distinct from the branched ones. The branched cells are very irregular, and the matrix somewhat fibrous.

myxo-chondromata, &c. Myxo-chondroma, frequently containing portions of adenoma, forms the ordinary parotid tumour. Occasionally a development of true fat-cells may take place in the central parts of a myxoma, thus indicating, as Virchow thinks, the relation of these tumours to embryonic fat. A few years ago I saw in consultation a case of an enormous abdominal tumour, which proved on examination after death to be a pure myxoma, weighing at least thirty pounds, the central parts of which contained an abundance of true adipose tissue. Such tumours as these have been spoken of as myxo-lipomata. I have since seen a similar abdominal tumour in a young man. After death it was found to be composed almost entirely of pure myxoma-tissue. A few small nodules of spindle-celled tissue were found in it, but no fat. Myxomata may occur in any part of the body. When superficial they often assume a polypoid form, as in the ordinary mucous polypus of the nose. Myxomata are not unfrequent in the subcutaneous cellular tissue, in nerves they form one variety of false neuroma, and they are occasionally met with in glands. Myxomata are usually non-malignant, but occasionally they recur locally after removal. If left untreated, they may cause death by ulceration of the skin taking place over them, leading to sloughing of the tumour with profuse hæmorrhage and foul discharge. Occasionally they may prove fatal from pressure on important organs, as in the case of the abdominal tumour above mentioned. The *Treatment* consists in the removal of the growth whenever an operation is possible.

III TUMOURS WHICH RESEMBLE IN STRUCTURE, MORE OR LESS PERFECTLY, ONE OF THE MORE COMPLEX TISSUES OF THE BODY.

A. **Myoma. Muscular Tumour.**—These tumours are of two classes: those containing striated and those containing non-striated muscular fibre. Striated

muscular fibre has, at present, been found only in a few congenital tumours, chiefly in large growths in or near the kidney, in which it is mixed with spindle-celled sarcoma and cysts lined with epithelium. Non-striated muscular fibre is found in abundance, as before mentioned, in the so-called fibroid tumours of the uterus (see p. 983), and of the prostate, but it is always associated with large quantities of fibrous tissue, so that the tumour is more properly spoken of as a myo-fibroma. The older tumours are found to be composed almost entirely of fibrous tissue, the muscular fibre-cells having undergone atrophy. Pure myomata have, in very rare cases, been found in connection with the œsophagus. Fagge has recorded an interesting case of this, which was accidentally discovered after death, at Guy's Hospital. It gave rise to no symptoms during life, although the tumour was as large as a good-sized egg. Myomata are always non-malignant.

B. **Neuroma. True Neuroma. Nervous Tumour.**—The term neuroma is clinically applied to any tumour growing on a nerve, whether it be a fibroma, myxoma, sarcoma, or true neuroma. The term should strictly be limited to those tumours in which there is an actual new growth of nervous tissue. Tumours containing newly formed nervous tissue are rare. Neuromata composed of grey matter (non-medullated fibres and ganglionic tissue) have been described, but they are so infinitely rare, that they need no further mention here. The vast majority of true neuromata are composed of bundles of medullated or white nerve fibres, interlacing with each other, or sometimes rolled up into masses, and separated by connective tissue, more or less rich in small cells. True neuromata occur only in connection with nerves. The bulbous extremities of nerves, often seen in stumps after amputation, have been shown by Valentin, Lebert, and others, to be specimens of true neuromata. True neuromata occur also without previous injury of the nerve. They are then frequently multiple. They cannot be diagnosed from other firm tumours of nerves. They are sometimes painful and tender, and sometimes not. The most characteristic sign of any tumour seated on a nerve is, that when the nerve upon which it is seated is put on the stretch by the position of the part, the tumour is almost immovable in a direction parallel to the course of the nerve, while it is more or less freely movable in the transverse direction. True neuromata are always non-malignant, and should not be interfered with in any way unless they give rise to serious inconvenience from pain.

C. **Angioma. Vascular Tumour.**—Under the name of angiomata are included only such tumours as are composed of vascular tissue of new growth, and not such swellings as arise from the dilatation of pre-existing vessels. The so-called cirsoid aneurism, or aneurism by anastomosis, being supposed to be due chiefly to a dilatation of pre-existing arteries, although doubtless accompanied by some new formation of vessels, is not usually included amongst angiomata, nor are the swellings formed by convoluted masses of varicose veins. True angiomata are usually divided into two classes :—*the plexiform angioma or telangiectasis*, and *the cavernous angioma*. The *plexiform angioma* is composed of a mass of tortuous and dilated capillaries bound together by connective tissue (Figs. 378, 379). The blood vessels comprising it are normal in structure. This forms the ordinary superficial nævus, mother's mark, or port-wine stain. It is, probably, always congenital. The *cavernous angioma*, or erectile tumour, resembles in structure the corpus cavernosum penis, being made

up by spaces, communicating freely with each other. The walls of the spaces are composed of fibrous tissue, and are lined with an endothelium resembling that of a vein. These tumours are sometimes distinctly circumscribed, and enclosed in a loose capsule of connective tissue; in other cases they are diffuse.

Fig. 378.—Nævus (188 diam.) infiltrating fat. The shaded bands represent vessels out of focus, the ends of some of them being shown in transverse section.

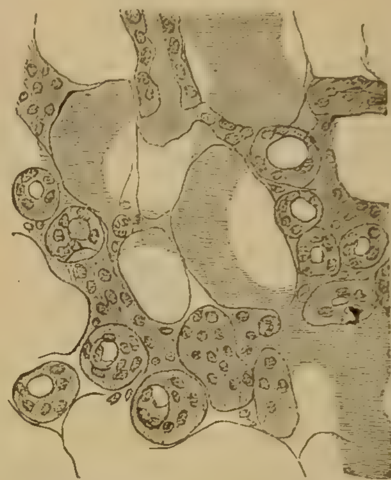


Fig. 379. (454 diam.) Shows the endothelium apparently almost obstructing the lumen of the vessels as the result of their contraction.

They are sometimes congenital, but often arise in young adult life. They are most common in the subcutaneous tissue, but have also been met with in muscles, and in the liver, spleen, and other internal organs. The mode of origin of these tumours is doubtful. They appear sometimes to develop as a result of an injury.

The symptoms and treatment of vascular tumour will be fully described in a subsequent chapter.

D. **Lymphangioma. Tumour composed of Lymphatic Vessels.**—These excessively rare tumours are composed of dilated lymphatic vessels communicating with each other, like the spaces of the cavernous angioma, the cavities containing lymph instead of blood. Virchow has described them as occurring congenitally in the tongue, forming one variety of hypertrophy of that organ (macroglossia). They are said to have been seen forming also pale, compressible, congenital tumours of the skin.

E. **Lymphadenoma. Tumour composed of Lymphatic Tissue. Lymphoma.**—Lymphadenomata are composed of tissue exactly resembling that of the follicles of the lymphatic glands, lymphoid or lymphatic tissue, the so-called "adenoid tissue" of His; but to avoid confusion, the term "adenoid" should never be used in connection with this structure, but reserved for tissues resembling those of the secreting glands. Lymphoid tissue (Figs. 380, 381) is characterized by a delicate reticulate stroma, in the meshes of which are packed numberless cells, in every way resembling the white corpuscles of the blood. The stroma is composed of fibrous tissue containing a few oval nuclei scattered through it, especially where the bands cross each other. The stroma may, in some cases, be increased in amount and thicker than that normally found in lymphatic glands. The vessels are abundant and in close connection with the stroma. The tumours are white or grey in colour, sometimes stained by

hæmorrhages. They vary considerably in consistence; sometimes they are soft and brain-like, and sometimes hard and tough. This difference depends upon the proportion borne by the cells to the stroma. The softer forms yield an abundant milky fluid on scraping, resembling the juice of a cancer. The lymphoid character of the cells in the fluid, however, at once shows the true nature of the growth. The development of these tumours forms the essential feature of the general affection known as "Hodgkin's disease." In this disease there is an enlargement of the lymphatic glands, accompanied in some cases by disseminated lymphoid tumours in the liver, spleen, kidneys, and other organs, and occasionally in the medullary tissue of bones. To this general form of the disease, Gowers applies the name of *lymphadenosis*. The chief general symptom is marked and progressive anæmia. The red corpuscles of the blood are diminished in number, and the white may or may not be increased. The increase in the white corpuscles is met with chiefly in those cases in which the tumours are soft and disseminated throughout the viscera, and more especially when the spleen is enlarged. The disease may occur at any age, but is most common in young adults. For the further symptoms, the reader must refer to works on medicine. Lymphadenoma comes under the care of the Surgeon only as it occurs in the lymphatic glands. The glands of the neck and axilla are most frequently affected. They form painless swellings, usually firm in consistence, and of slow growth, and are at first indistinguishable from simple hypertrophy or chronic inflammatory enlargement. The glands remain distinct till they have acquired a considerable size; but later on they often fuse together, forming a large lobulated mass. While they remain distinct, they form no adhesions to surrounding parts, and can be easily removed; but when the growth extends beyond the capsules of the glands, it may infiltrate surrounding structures. They show scarcely any tendency to caseation, and never soften or suppurate. The skin covering them is not adherent and retains its natural colour. The affection may remain for a long time, or even permanently, limited to one set of glands. In these cases, as a rule, the stroma is in great excess, and the tumours are hard and fibroid. After a time they may cease to grow. When large numbers of glands are affected and disseminated growths are present in the viscera, the growths are usually, but not always, softer, and the case almost inevitably terminates fatally after two or three years. Death may take place from the general disease, or from the effects of local pressure, especially when the growth extends beneath the sternum, or presses on the trachea or recurrent laryngeal nerve.

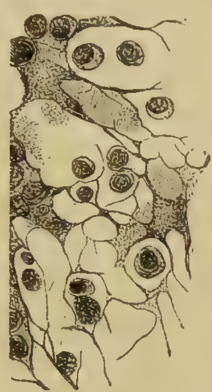


Fig. 380. — Lymphadenoma. (454 diam.) Some of the cells have been removed to show the arrangement of the stroma.

Fig. 381.—(188 diam.) Shows general arrangement.

Lymphomata frequently come under the observation of the Surgeon.

affecting a single gland or group of glands unaccompanied by any constitutional disturbance. In these cases the disease seems to be a mere hypertrophy of the affected glands; and perhaps, strictly speaking, should hardly be classed with tumours. The diagnosis of lymphadenoma in the early stages is practically impossible. At a later period, the great enlargement of the glands, and the constitutional symptoms, indicate the nature of the case. The absence of a local cause of irritation, and the want of any tendency to caseation or suppuration, serves as a rule to distinguish it from chronic inflammation of the glands. The question of removing the enlarged glands often comes before the Surgeon. If the affection is local, and the general health fairly good, the operation may safely be undertaken. If there is very marked anæmia, or if there be a high temperature, and especially if the tumours are very numerous, the spleen enlarged, and the white corpuscles distinctly increased in number, any operative interference should be avoided unless it seems possible to relieve the patient from imminent death from pressure on the trachea.

F. **Papilloma. Tumour resembling the Papillæ of Skin or Mucous Membrane.**—A papilla is a more or less pointed projection composed of areolar or homogeneous connective tissue, surrounding a capillary loop and covered by epithelium, which may consist of many layers, as in the skin, or of only one, as in the intestine. Lymphatic spaces or capillaries are present in the areolar tissue. The tumours which pass under the name of papillomata are usually mere hypertrophies of the normal papillæ of the part on which they grow, and are covered by the variety of epithelium normal to the part. The papillæ of which they are composed differ from those normal to the part in size, shape, and vascularity. Thus, instead of merely microscopic papillæ, such as are normal to the skin, we may have growths sometimes reaching the size and presenting the appearance of the head of a good-sized cauliflower. Instead of simple papillæ, we may have branched growths subdividing again and again, and connected with the parent tissue only by a narrow stalk. The vessels of these growths are always abundant, and frequently dilated to a considerable size. The connective tissue forming the basis of the papillæ is more or less crowded with small round cells, according to the rapidity of the growth. Sometimes the deeper layers of the epithelium are darkly pigmented. Malignant tumours of various kinds when seated on a free surface may assume a papillary form, but these must not be confounded with papillomata. On the other hand, a papilloma may by invisible degrees merge into an epithelioma, either squamous or columnar, as the case may be, the distinction between them sometimes being impossible, even with the help of the microscope. It may, however, be broadly stated that so long as the tumour maintains a simple papillary form, the epithelium being purely superficial, and showing no tendency to burrow between the papillæ into deeper parts, and so long as the base of the tumour is not composed of masses of small round cells infiltrating the surrounding structures, we may at least hope that the tumour is non-malignant. In other cases, such as the common warts or gonorrheal warts, we know certainly that the growth is simple. Papillomata vary in hardness and softness, according to the parts on which they grow, and the amount and nature of epithelium with which they are covered. Thus the common corn or wart, being thickly covered with horny epithelium, is hard, while the papillomata of the rectum, being thinly covered with columnar epithelium, are always soft.

The chief forms of papilloma are :—corns, simple warts, condylomata and mucous tubercles, and some forms of polypi and villous tumours.

Corns consist of an undue development of cuticle, with a slight increase of the vascularity of the subjacent cutis ; subsequently the papillæ themselves become enlarged, especially when the irritation has been prolonged or considerable. A soft corn is merely one which from its situation is kept constantly moist, so that the newly formed scaly epithelium, instead of forming a dense crust, peels off, leaving the vascular and sensitive papillæ but thinly covered.

Warts are the result of a primary hypertrophy of the papillæ, accompanied by the formation of new vessels, and a great increase in the development of the epidermis, which forms laminated strata, and sometimes produces, in the hollows between the papillæ, masses with a concentric arrangement of the cells, closely resembling the nest-like structures seen in epithelioma. The true warts are most commonly found on the skin, and are then often very hard and horny ; sometimes they may develop a long horn-like growth. Softer varieties are, however, found on the muco-cutaneous surfaces, especially

Fig. 382.—Papilloma of Soft Palate. (40 diam.).
a. Superficial epithelium, containing a few vessels which are cut transversely.
b. Younger epithelium : in the deeper parts the cells are more deeply stained and radiate from the centre.
c. Connective tissue forming the papillæ, into the ramifications of which it is prolonged.
d. Vessels cut obliquely.

of the prepuce and vulva, and are usually of a specific origin. They may also occur on the mucous membrane of the mouth or soft palate (Fig. 382), and they are not uncommon in the larynx. Warts may be the result of a local irritation, but in many cases they appear to depend as much upon some constitutional condition.

The warty growths from the vulva, as the result of gonorrhœal irritation, may reach the size of a fœtal head. Simple cutaneous warts are often pigmented, being of a bluish-black colour. In these the papillæ may not be evident to the naked eye, the spaces between being filled up with epithelium, but the papillary structure is readily demonstrated by the microscope.

In **Condylomata and Mucous Tubercles** the enlarged papillæ are soft, and contain a great abundance of small round cells, giving evidence of their rapid growth. They occur about the anus and in the perinæum and folds of

the nates, as well as occasionally in the larynx and fauces. They are always dependent on a syphilitic taint. When situated on the mucous membranes, they are often pointed, somewhat pendulous, nodulated on the surface, very vascular, and bleed readily when touched; but when they occur on a muco-cutaneous surface, they are flattened, expanded, soft, and white, constituting the true condylomata or mucous tubercles.

Some forms of **polypi** are properly classed amongst papillomata. Thus the simple polypus of the rectum may be a soft papilloma bearing columnar epithelium. In some rare cases, the epithelium has been found to be scaly. The papillæ may branch again and again, the peduncle being comparatively small. It is difficult, however, to draw any accurate line between such papillomata and the columnar epithelioma to be described hereafter.

The common form of **villous tumour** of the bladder, frequently described as "villous cancer," should also undoubtedly be included under papillomata. This tumour is composed of long delicate processes floating freely in the cavity of the bladder, attached only at their bases. They each consist of a dilated capillary loop, surrounded by an almost homogeneous connective tissue, containing a few scattered round or oval cells, and covered with an epithelium of an irregular shape, often resembling spindle-cells in form, and similar to that naturally lining the bladder. This epithelium is very difficult to find, as it soon separates by maceration in the urine after death. The base from which the villi grow is composed merely of fibroid tissue tunnelled in all directions by dilated vessels. These tumours, if left unrelieved, invariably terminate fatally from the abundant hæmorrhage to which they give rise, and the effect they have in interfering with the escape of urine from the bladder; but they never give rise to secondary deposits nor invade surrounding structures, and are consequently non-malignant. They will be more fully described under diseases of the bladder.

The general principles of *Treatment* of these affections consist in their removal by excision, ligature, or caustics, according to their size, situation, and attachments. Excision is usually preferable when they are of large size. If they are seated on a mucous surface, and are pedunculated, the ligature is the safest means of removal. In many cases Paquelin's cautery will be found very useful in removing large papillary growths. Small warty growths on the skin or on a muco-cutaneous surface may be conveniently destroyed by caustics.

The term **"polypus"** may perhaps be more conveniently defined here than elsewhere. It is purely clinical, and has no pathological meaning. It merely means a tumour growing from the mucous surface lining a cavity, having a distinct peduncle and a rounded, oval, or papillary form. Thus the ordinary polypus of the nose is usually a myxoma, and the malignant polypus a sarcoma. Polypus of the uterus is a fibroma or myofibroma, and polypus of the rectum often a papilloma, and sometimes a form of cancer. Simple polypi are usually covered by a prolongation of the mucous membrane from which they grow. Thus the mucous polypus of the nose is covered by a membrane bearing ciliated epithelium.

Adenoma. Glandular Tumours.—These tumours resemble secreting glands in structure. Secreting glands are racemose or tubular, and consequently adenomata are divided into two corresponding classes.

The **Tubular Adenomata** are composed of masses of tubules resembling the crypts of Lieberkühn, some closed and some open on the surface. They

are usually papillary, and seated on some parts of the intestine. They often form polypoid tumours. When simple and with well marked papillæ, they might perhaps be more properly spoken of as papillomata, and they were consequently mentioned under that class. When showing the well marked malignancy so common to these growths, they are classed with carcinomata,

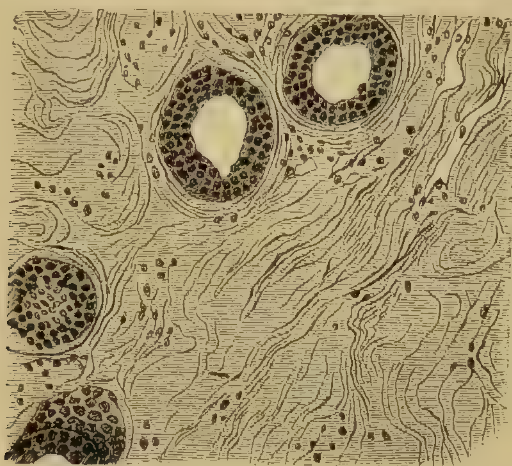


Fig. 383.—Adenoma of Mamma, of slow growth (188 diam.). Stroma bears a large proportion to the spaces, it consists of well-formed fibrous tissue. Tubes contain more than one layer of epithelium.

either under the name of columnar epithelioma or adenoid cancer. They will, therefore, be more fully described hereafter.

The **Racemose or Acinous Adenomata** resemble in structure more or less perfectly a racemose gland, and are found always in connection with such

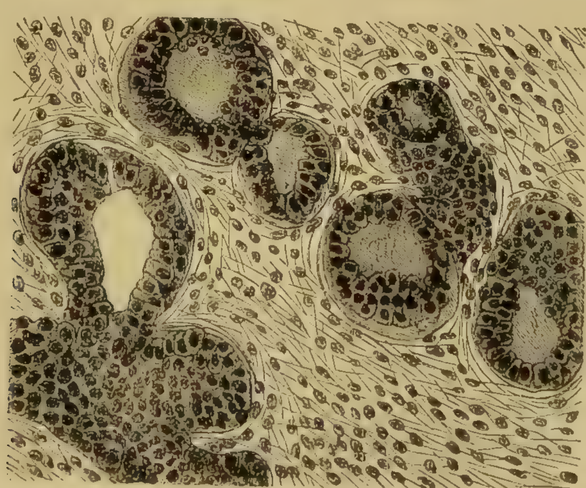


Fig. 384.– Adenoma of Mamma, rapid growth (188 diam.). This is sometimes spoken of as adenosarcoma; the epithelium in the acini is arranged in several layers, the stroma contains many oval cells and some fibres.

organs (Figs. 383, 384). They are composed of rounded or irregular spaces lined with a peculiar small epithelium, somewhat square or rounded in form, and frequently many layers deep. The spaces communicate with each other, either directly or by means of duct-like channels. The acini, which are more or less widely separated, are bound together by fibrous tissue, bearing vessels, and containing cells varying in shape and number. In the most

typical forms the cells are merely such as are seen in ordinary connective tissues; but if the tumour be growing rapidly, large numbers of small round or oval cells are found (Fig. 384). Sometimes the tissue between the acini may be composed entirely of spindle-cells, in fact, may have the structure of a spindle-celled sarcoma; the tumour is then often spoken of as an adeno-sarcoma. Sometimes tissue resembling that of a myxoma may be found. Very frequently the acini become dilated into cysts, varying in size from a pin's head to a walnut, or larger; this forms the so-called cystic sarcoma of the mamma. Not unfrequently in such cases cauliflower-like growths, similar in structure to the rest of the tumour, may be found projecting into the cysts (intracystic growths—proligerous cysts of the mamma). These tumours are infinitely most frequent in the mamma, but they are sometimes seen in connection with the parotid, and have been recorded as growing from the racemose glands of the soft palate, from the lachrymal gland, and from the sebaceous glands of the skin. In the parotid they are often mixed with myxoma and enchondroma. They are rounded or oval in shape, perfectly circumscribed, and surrounded by a fibrous capsule. They are hard and elastic, occasionally presenting points of fluctuation when containing large cysts. They are always non-malignant, and there is no reason to believe that they ever assume a carcinomatous character. Their clinical features and treatment will be fully discussed in the chapters on the diseases of the organs in which they occur.

IV.—TUMOURS COMPOSED OF TISSUE WHICH IS EITHER PURELY EMBRYONIC, OR IS UNDERGOING ONE OF THE PRIMARY MODIFICATIONS SEEN IN THE DEVELOPMENT OF ADULT CONNECTIVE TISSUE:—SARCOMATA.

The large group of tumours now classed together under the name of sarcomata includes many which were, till comparatively recently, known by a variety of other names, and grouped in other divisions: and the term sarcoma, which has now received a definite meaning, was formerly applied to almost any soft fleshy growth. Almost all soft sarcomata of bones, the glioma or glio-sarcoma of the eye, sarcomata of secreting glands, and lymphatics, were formerly called soft cancer; the melanotic sarcoma,—melanosis or melanotic cancer, and the ossifying sarcoma,—osteoid cancer; many firm sarcomata have been described as scirrhus, and soft sarcomata broken down by hæmorrhage as blood-cysts. Lastly, the tumours known as fibro-plastic, fibro-nuclear, recurrent fibroid, malignant fibroid, and myeloid, have all been brought into the great class of sarcomata. These tumours may grow in any part of the body. They may present every variety of consistence, colour, and shape; they may be circumscribed or diffuse; they may be as innocent as a fatty tumour, or as malignant as the worst form of cancer. The anatomical type of sarcoma is found in embryonic tissue, a description of which has been given in a former page (p. 964). Its pathological analogue is seen in the products of inflammation, but between these and sarcoma are many differences. The products of inflammation, supposing they live, show a tendency towards development into some more perfect tissue; but in a sarcoma the older parts of the growth show no higher development than the most recent, the same type of structure being as a rule maintained throughout. Inflammatory new growths tend speedily to limit themselves, sarcomata to grow indefinitely. In sarcoma, the individual elements are often larger than those seen in inflammation.

The cells of sarcomata vary greatly in shape and size, and it is chiefly according to these variations that this group is subdivided. The cells consist simply of a mass of protoplasm surrounding one or more nuclei, and enclosed in no cell-wall. They may be small and round, exactly resembling the white corpuscles of the blood, or large and round, looking almost like epithelium-cells; they may be oval, spindle-shaped or fusiform, stellate or tailed; large mother-cells crammed with nuclei may be found, and occasionally the cells are pigmented. The intercellular substance may be scanty or abundant, homogeneous or fibrous, but whenever it is recognizable it is seen to penetrate between the individual cells in the greater part, if not in the whole of the tumour, and thus a broad distinction is established between these growths and carcinomata, in which the stroma forms alveolar spaces, the cells lying free within them. Occasionally the growth may ossify. The blood-vessels of sarcomata are usually abundant and thin-walled, resembling those of newly formed granulations. This makes these tumours prone to bleed, both into their own substance and externally, and may perhaps account for the readiness with which many sarcomata propagate themselves in the direction of the circulation. Of the lymphatics of sarcomata we know little or nothing. These growths are usually prone to early degeneration. They most commonly undergo fatty degeneration in their central parts, but occasionally they may calcify; mucous softening also may take place. When they reach the surface they may slough and ulcerate, forming foul cavities, sometimes of great size. Cysts are of frequent occurrence in some forms of these tumours. On scraping after a section has been made, sarcomata do not yield a milky juice when fresh, but after about twenty-four hours it can often be obtained. Some sarcomata are distinctly circumscribed and enclosed in a fibrous capsule, others infiltrate surrounding parts like the carcinomata. Sarcomata are most frequent in youth and middle life. As a rule, it may be said that sarcomata infect the system generally through the medium of the blood-vessels, while carcinoma is disseminated chiefly by the lymphatic system. This rule has many exceptions, yet nothing is more common than to see secondary growths of sarcoma in the lungs, liver, and other organs, without the lymphatic glands having ever been affected. The reverse is certainly the rule in carcinoma. It may be broadly stated also that, the more closely a sarcoma approaches to fully developed connective tissue in its structure, the less likely it is to prove malignant; but this rule is not free from exceptions. Sarcomata vary greatly in their rate of growth, some proving fatal in less than a year, others lasting many years without attaining any considerable size. Sarcoma-tissue sometimes occurs mixed with other kinds of growth.

VARIETIES OF SARCOMA.—**Small-Round-celled Sarcoma. Granulation Sarcoma. Encephaloid Sarcoma.**—These tumours were formerly included among soft or encephaloid cancers. They resemble in structure the superficial layers of granulations, being composed of small round cells about the size of a white blood-corpuscle, or a little larger, each containing a round or oval nucleus, and embedded in a homogeneous intercellular substance (Fig. 385). Sometimes the intercellular substance is scarcely perceptible, sometimes it is more abundant, as in the accompanying figure. It may be more or less distinctly fibrillated. The tumour may thus closely resemble a lymphadenoma, but on careful examination the stroma will be found not to be so clearly reticular. These tumours are soft, sometimes even pulpy, and grey or whitish in

colour. They very often infiltrate surrounding parts. They are excessively vascular, and often present scattered patches of hæmorrhage or cysts resulting from extravasation of blood. They yield no milky juice when quite fresh, but when decomposition sets in, it can easily be obtained by pressure or scraping. Their chief seats are the skin, bones, subcutaneous areolar tissue, muscles, and occasionally in glands. Their diagnosis cannot be accurately made till after removal. They show a malignancy equal to that of the worst cancers.

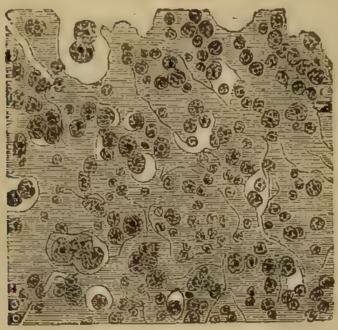


Fig. 385.—Round-celled Sarcoma, from a large tumour in the muscles round the upper end of the femur (188 diam.). The cells vary in size and have a very clear nucleus and nucleolus; the matrix which has shrunk away from the cells is faintly granular.

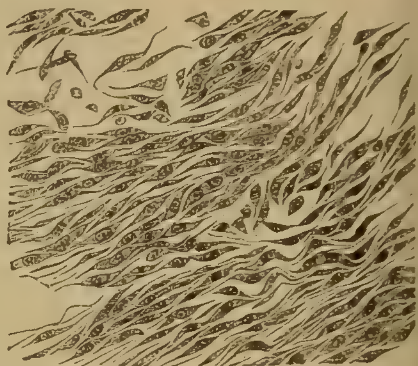


Fig. 386.—Spindle-celled Sarcoma, from subcutaneous tissue of groin (188 diam.). Cells of medium size; no intercellular fibres.

Their growth is rapid, and they early give rise to secondary deposits, especially in the lungs, and the lymphatic glands are frequently affected.

One form of small round-celled sarcoma has been described by Virchow under the name of **Glioma**, from its resemblance in structure to the neuroglia or connective tissue of the brain. It is composed of an excessively delicate areolar stroma, having round cells embedded in its meshes. These tumours vary much in consistence, being sometimes soft and sometimes quite firm. They occur almost invariably in connection with the nerves or nervous centres. The tumour formerly known as soft cancer of the eyeball is in fact a glioma arising from the retina. It is most common in young children, and frequently runs a malignant course, projecting beyond the eyeball, infiltrating surrounding parts, and giving rise to secondary deposits.

Spindle-celled Sarcoma. Fasciculated Sarcoma. Recurrent Fibroid Tumour. Fibro-plastic Tumour. These tumours are composed of spindle-shaped, fusiform, or oat-shaped cells, either lying closely in contact with each other or separated by a homogeneous or fibrous intercellular substance (Fig. 386). The cells vary greatly in size in different tumours, but are usually tolerably equal in the same growth. They may be little more than $\frac{1}{1000}$th inch in length, or they may reach entirely across the field of the microscope. This has given rise to the distinction between large and small spindle-celled sarcomata. The intercellular substance is usually more abundant and more fully developed into fibrous tissue in the small than in the large-celled growths: and it is the former, therefore, that gradually merge into fibromata, so that it is often difficult to determine under which heading to class them, and some writers have given them the name fibro-sarcoma. All spindle-cells, large or small, contain an oval nucleus with one or more nucleoli. The cells are usually

arranged in bands crossing each other in various directions, often giving the growth a fasciculated or fibrous appearance, and if a band happens to be cut transversely it presents the appearance of a group of small round cells. The vessels, as in other sarcomata, are abundant and thin-walled.

The *small spindle-celled sarcomata* are usually firm in consistence, and of a pinkish or white colour, the central parts being yellow from fatty degeneration. Occasionally they contain cysts filled with straw-coloured fluid, and they may closely resemble in aspect the common fibroid tumour. They grow by preference in fibrous structures, as fasciæ, skin, or tendons; they may occur in intermuscular spaces, or occasionally in the sheaths of nerves. Thus I amputated a leg a few years ago for a large tumour of this kind seated on the posterior tibial nerve. Though these tumours are usually distinctly circumscribed and sometimes encapsuled, and run a perfectly innocent course, in many cases they show an extraordinary tendency to local recurrence after removal; but it is rare for them to give rise to secondary deposits in internal organs. Paget describes these growths under the name of *recurrent fibroid tumours*, and relates several instances of them. One was a tumour of the upper part of the leg, which between 1846 and the end of 1848 had been removed five times, and reappeared for the sixth time after the last operation, when, as it had become large and ulcerated, amputation was deemed advisable; this procedure, however, was followed by death. The examination of the third tumour presented "very narrow, elongated, caudate, and oat-shaped nucleated cells, many of which had long and subdivided terminal processes;" in the last removed tumour, the cells were generally filled with minute shining molecules, as if fatty degeneration had taken place. In another case, a tumour of the shoulder had been removed, and returned four times between May, 1848, and December, 1849, reappearing in the following year for the fifth time; it, however, after a time became stationary, and many years afterwards the patient, but for the presence of the tumour, might be considered to be a strong and healthy man. Paget relates also a case in which, between 1839 and 1851, Syme removed a tumour of this kind five times from the upper part of the chest: it recurred a sixth time and was followed by death. He refers also to a case by Gluge, in which a similar tumour was five times removed from the scapula, its sixth reappearance being followed by death. The most interesting of all is a case by Maclagan, in which four removals were performed in the course of thirty-six years, twenty-three years intervening between the second and third removals, and eleven between the third and fourth. Since this form of tumour was first described by Paget, a number of instances have been recorded by British and continental Surgeons. These recurrent tumours appear to become more malignant in the later than in the earlier recurrences, becoming more painful, rapidly degenerating, and giving rise to an ulcerating fungus, which eventually proves fatal by exhaustion and hæmorrhage. The cells will then be found to have become larger, and the intercellular substance softer and devoid of fibrillation; and, in fact, they merge into the large-celled form of spindle-celled sarcoma. This is clearly shown by a case which occurred under my care at University College Hospital. A tumour as large as a full-sized turnip was removed from the shoulder of a middle-aged man, and was found to be slightly connected with the spine of the scapula. On examination it presented all the characters of a spindle-celled sarcoma, consisting almost entirely of densely-packed fusiform cells, with oval or oat-shaped nuclei. A small mass

reappeared before the wound had completely healed, and on examination presented a much larger proportion of oval cells and spindle-cells, now having double nuclei. It recurred a second time, and now but few well-formed spindle-cells were found, but the tumour was chiefly composed of oval and flask-shaped cells, or rather masses of protoplasm, in which numerous nuclei were embedded. A portion of the spine of the scapula, which was removed with the tumour, showed that the growth had sprung from the cancellous tissue of the bone.

Large spindle-celled sarcomata, formerly often spoken of as fibro-plastic tumours, are much softer than the variety last described. They are usually of a pinkish colour, frequently stained dark-red in parts from extravasations of blood, and if of any size, their central parts are opaque and yellow from the effects of fatty degeneration. They yield more or less transparent viscid juice on scraping, mixed with fragments of the growth. They may be distinctly circumscribed and encapsuled, but not infrequently they invade surrounding parts. They often contain cysts of some size, sometimes filled with straw-coloured fluid and sometimes with blood or a blood-coloured liquid. These tumours form frequently in connection with bones, especially commencing under the periosteum of the shafts of long bones or about the bones of the face or nose. A few years ago I amputated a thigh at the hip-joint in University College Hospital, for a large tumour of this kind growing beneath the periosteum of the femur ; and in another case the arm was removed by Heath for a similar growth. Both had caused spontaneous fracture of the bone, and both ultimately proved fatal from internal deposits. These tumours when affecting bone, must not be confounded with the myeloid, which they closely resemble. Large-spindle-celled sarcomata grow also from fasciæ and inter-muscular spaces, and not unfrequently from glands, especially the mamma ; and they may be found in rare cases in almost any situation. They very often run a malignant course, giving rise to secondary deposits in internal organs. Their tendency to local recurrence after removal is very great.

From what has been said above, it will be seen that the spindle-celled sarcomata form a very large and important group of tumours, varying greatly in clinical characters and structure, but all resembling each other in the broad feature of the spindle cell forming the predominant element. As to their *prognosis*, it may be broadly stated that the more they approach the structure of the spindle-celled growth found in cicatrizing wounds, the less likely they are to give rise to general infection of the system ; but that even the simplest may recur locally after removal, and consequently too guarded a prognosis cannot be given in such cases.

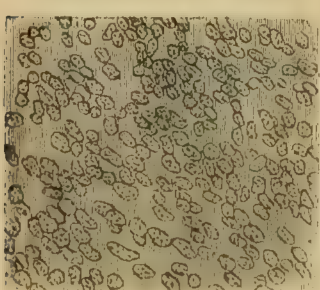


Fig. 387.—Oval-celled Sarcoma (188 diam.).

Oval-celled Sarcoma (Fig. 387) may be looked upon as merely an extremely rapidly growing and malignant spindle-celled tumour. Thus we saw in the case above mentioned, that, as the rapidity of the growth increased with each recurrence, the spindle-cells became replaced by large oval cells with two or more nuclei. But similar growths may occur primarily. They are soft, rapidly growing, rarely completely circumscribed. They are of a delicate pinkish colour, and yield an abundant slimy albuminous fluid on section. I have twice had occasion to

remove such growths from the neighbourhood of the mamma. In one case it recurred locally after the wound had healed, and in a short time formed an enormous tumour, larger than the patient's head. She refused a second operation, and the case soon terminated fatally. In the other, although a large portion of the pectoral muscle was removed with the tumour, it recurred before the wound healed, and, in spite of the free application of caustics, grew with enormous rapidity, in a few weeks forming a fungating mass as large as a fœtal head.

Myeloid or Giant-celled Sarcoma was formerly often classed under fibro-plastic tumours, and sometimes probably as soft cancer. It was described by Abernethy under the name of "albuminous sarcoma." It was first fully described by Lebert, and its clinical and anatomical characters have been carefully investigated by Paget. It is nearly related to the spindle-celled group of sarcomata.

The most characteristic feature of myeloid tumours is the presence of large, many-nucleated masses of protoplasm—the so-called myeloid cells—somewhat resembling the cells found in the marrow of fœtal bones (Figs. 388, 389). They are often of great size, sometimes $\frac{1}{100}$th or even $\frac{1}{50}$th inch in diameter, and extremely irregular in shape, having processes projecting from them in all

Fig. 388.—Myeloid Sarcoma from the Lower Jaw (454 diam.). The small cells have shrunk away from the myeloid cells, the former vary from round to spindle shape.

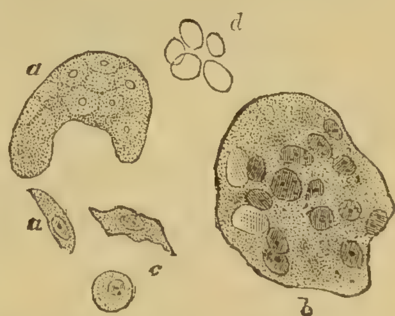


Fig. 389.—Constituents of a Myeloid Tumour (454 diam.).
a a'. From a fresh scraping.
b, *c*. From a stained section.
d. Transparent nuclei from a fresh scraping.

directions. The nuclei vary from eight or ten to thirty or forty in number, and are oval in shape, with distinct and highly refracting nucleoli. These myeloid cells are embedded in masses of spindle-shaped or roundish cells, between which there is either no intercellular substance, or merely a small quantity of homogeneous gelatinous material. These growths are extremely vascular; so much so, that the whole mass may pulsate distinctly. Myeloid tumours frequently contain cysts, often of considerable size. On section they present a soft gelatinous appearance and brittle structure; they usually yield a slimy fluid on scraping, mixed with fragments of the tumour; they are of a pink colour at their growing margin, while the central parts are of an opaque yellow from fatty degeneration. The intermediate parts usually present patches of a dark maroon colour, caused by extravasations of blood.

Occasionally patches of ossification may be found. Myeloid tumours grow almost exclusively from bone, and by far most frequently from the medullary cavity or cancellous tissue at the head of a long bone. They attain to a large size, sometimes slowly and gradually, and at other times with very great rapidity. The growth gradually causes absorption of the bone, but at the same time a new deposit takes place from the periosteum, so that the tumour is enclosed in a thin bony shell, which, on pressure, yields the peculiar sensation known as an "egg-shell crackling." On reaching a cartilage-covered surface it pushes the cartilage before it, but rarely if ever perforates it. On examination of such a tumour after removal, a bony plate will frequently be found separating it from the medullary canal. In other cases it may extend a long distance, infiltrating the medulla. Myeloid tumours are most common at the lower end of the femur, the upper end of the tibia, and the upper end of the humerus. They also, when growing from the jaw-bones, form one variety of epulis. I have removed them from the lower end of the radius, and from the metacarpal bones (Figs. 390, 391). In the majority of cases they may be safely removed without the prospect of recurrence, but occasionally they return after removal. The true myeloid rarely, if ever, gives rise to secondary deposits in the lymphatic glands or internal organs. Myeloid tumours are said to have been seen in the parotid region and the mamma, but this is doubtful.

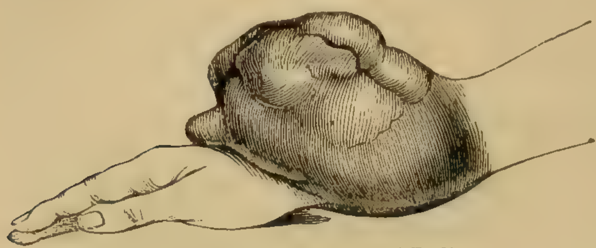


Fig. 390.—Myeloid Tumour of Radius.

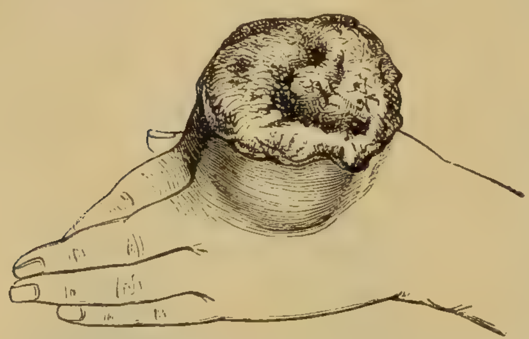
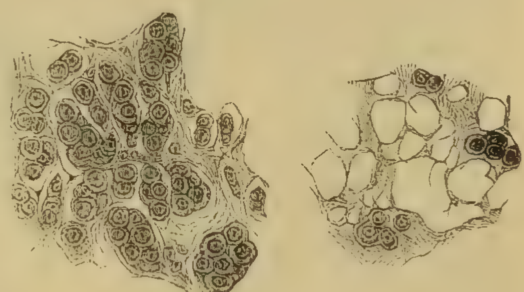


Fig. 391.—Myeloid Tumour of the Metacarpal Bones of the Index and Middle Fingers. Successful Removal of those Bones and Fingers.

Ossifying and Osteoid Sarcomata.—These tumours were formerly classed amongst the cancers, under the name of osteoid cancer. Almost any form of sarcoma may undergo ossification. Thus round-celled, spindle-celled, and myeloid sarcomata may occasionally show abundant formation of bone. The development of bone in these growths seems to give rise to no radical change in their nature. They still show the same tendency to unlimited growth and sometimes the same liability to recur locally or to give rise to secondary deposits in distant parts. The secondary deposits develope bone like the original growth. The bony parts of these tumours usually present the appearances of true bone, but somewhat irregular in structure. Occasionally tumours growing from bone are met with, which present the structure of the growing tissue found beneath the periosteum in inflammation or in normal growth; that is to say, small round or polygonal cells with simple or multiple nuclei, separated by a small amount of homogeneous or fibrillated intercellular substance. These growths readily ossify; they form under the periosteum, and the bone beneath is often thickened, so that the medullary canal may be obliterated.

They show a considerable tendency to local recurrence after removal. In rare cases, ossifying sarcomata are found unconnected with pre-existing bone.

Alveolar and Large Round-celled Sarcoma.—In these rare tumours, which were first clearly described by Billroth, the cells are of considerable size, sharply defined, and each containing a large round nucleus (Fig. 392). They thus closely resemble epithelium-cells in appearance. They are separated from each other by a distinct and somewhat abundant fibrous stroma, but on careful examination this stroma will be found to penetrate between the individual cells. In some parts, probably from the pressure of the growing cells, the stroma may be partially absorbed, so that the cellular elements seem to lie in alveolar spaces in immediate contact with each other, but further examination of the tumour will always show parts where the stroma and cells are closely intermixed. On carefully pencilling out the cells from a thin section, a delicate stroma is brought into view, passing between the individual cells and subdividing the spaces formed by the bands, which give the growth its alveolar and cancer-like appearance. In some cases, however, the distinction between these tumours and scirrhus is very difficult. Alveolar sarcomata occur chiefly in the cutis, bones, and muscles. In the cutis they form hard rounded tumours, often multiple, of tolerably slow growth, and free from pain. They lead ultimately to ulceration of the skin and the formation of an intractable sore. In the bones, they are more often single and of more rapid growth. Three cases affecting the cutis have occurred in University College Hospital during the last few years. In the first, three amputations were performed for recurrence of the growth after removal, by Christopher Heath, commencing with one finger and ending with the fore-arm. The tumour, when first removed, was supposed to be a specimen of scirrhus of the skin. Finally similar tumours appeared in the cheek and scalp, and two more operations were performed. The man died shortly afterwards, and there was reason to believe that the cause of death was a similar growth in the lung. The whole history of the case lasted more than seven years, and at no time had the lymphatic glands been affected. In the second case, Berkeley Hill amputated the leg for a number of similar tumours situated below the knee, from one of which the accompanying drawing is taken; and in the third, Marcus Beck amputated half the foot for a similar growth, which commenced at the roots of the second and third toes, and had recurred three times after removal.



A B

Fig. 392.—Alveolar Sarcoma from Skin of Leg (188 diam.).
A. To show general arrangement.
B. After prolonged pencilling shows the intercellular as well as the alveolar stroma.

Plexiform Sarcoma or **Cylindroma.**—A rare form of tumour has been described by Billroth, Sattler, and others, under this name. It consists of small cells of a polygonal form arranged in cylinders communicating with each other in a plexiform manner, between which is a varying quantity of hyaline, or finely fibrillar connective tissue. Knob-like projections or globe-like masses of the cells are also met with. The individual cells are in immediate contact with each other, without any apparent intercellular substance. The peculiar

appearances are supposed to be due to a hyaline or mucoid degeneration of the walls of the vessels and the neighbouring cells of the tumour. The remaining cells are squeezed together, and thus assume the form of columns of polygonal cells. Much doubt exists, however, as to the exact mode of origin of these growths. At first sight a section of a plexiform sarcoma closely resembles that of an epithelioma, but a careful examination with a high power shows its true nature. The tumours seldom reach any great size. They are soft and gelatinous, and of a dirty white colour. They are most commonly met with in the brain, the orbit, and sometimes in the salivary glands. Butlin has recorded a case in which the tumour formed in the popliteal space. It recurred after removal, and its true sarcomatous nature was shown by the fact that the recurrent growths assumed the form of the ordinary round-celled sarcoma.

Melanotic sarcoma is usually of the spindle-celled variety, but frequently contains large numbers of round or oval, intermixed with the fusiform cells (Fig. 394). The spindle-cells are of large size, and there is no fibrous stroma between them. The pigment is seen as brownish granular matter in the interior of a certain number of the cells, the rest remaining colourless. The proportion of coloured cells varies in different specimens. In the secondary tumours, it has been shown by R. J. Godlee that the new cells follow the lines of the vessels. These tumours are usually sharply circumscribed, both to the naked eye and the microscope. They are soft, sometimes almost pulpy, round or oval in shape, and varying in colour from dark brown to the most intense black. They arise especially from structures in which pigment naturally exists, namely, the skin (Fig. 393) and choroid coat of the eye (Fig. 395). They may, however, occasionally arise primarily in the lymphatic glands. They are of rapid growth, and occur usually in middle life. Melanotic sarcoma is one of the most malignant of all forms of tumour. The secondary deposits occur in every organ and tissue in the body, and they may apparently be propagated entirely by the vascular system, the lymphatic glands escaping any contamination, or they may be distributed by both the vascular and the lymphatic systems. It may be broadly stated that if a melanotic sarcoma reach the size of a filbert secondary deposits have in all probability occurred, and no local treatment can cure the patient, although, by relieving him of one source of infection, it may retard death. Although showing this terrible general malignancy, the local malignancy of melanotic sarcoma is not great. It may reach a large size without ulcerating;

Fig. 393.—Melanotic Sarcoma commencing in the Papillæ of the Skin (Malignant Mole). (40 diam.)
a. Superficial epidermis.
b. Deeper layers of Epidermis, which is deficient to the right of the drawing.
c. Prolongation of the Epidermis into the centre of the growth.
d. Sarcoma tissue, chiefly non-pigmented but with scattered melanotic patches.
e. Connective tissue round the tumour infiltrated with small round cells.
f. Surrounding connective tissue with vessels.

it is frequently distinctly encapsuled, and, if removed freely, often does not return in the scar. The secondary tumours form in every part of the body; constantly in the lungs and liver, almost constantly in the brain and spinal cord, spleen, kidneys, and subcutaneous tissue; very often in the heart, intestines, medulla of bones, and lymphatic glands. Like the cells of the primary tumour, some of the secondary growths are found to be pigmented and some not. The *diagnosis* of melanotic sarcoma is made by the colour and rapidity of the growth. It must not be confounded with the simple pigmented wart. This is always of slow growth, more or less firm, pedunculated and

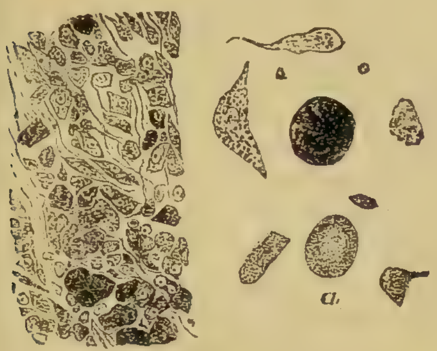


Fig. 394.—Melanotic Sarcoma, from a Secondary Tumour in the Heart. Figure to left (188 diam.) shows the different degrees of pigmentation and variety of shape in the different cells. Figure to right (454 diam.). From a fresh scraping, illustrates the differences in the size of the pigment-granules.

Fig. 395.—Melanotic Sarcoma of Eye—natural size. The eye has been divided in the antero-posterior diameter. The tumour started from the choroid and afterwards burst through the sclerotic.

lobulated. It must be remembered, however, that melanotic sarcoma may start from a wart of this kind, or from a congenital mole. As to true melanotic cancer, that is to say, pigmented encephaloid or epithelioma, it is doubtful if such a growth exists, at any rate, it must be of extreme rarity. The only *Treatment* of melanotic sarcoma is the immediate removal of the tumour, unless secondary deposits can already be recognized.

Psammoma is a rare form of tumour found only in connection with the membranes of the brain. The chief characteristic of these growths is the presence of small concentric calcareous globules, the so-called "brain-sand." They are composed chiefly of peculiar flattened cells. They give rise to no symptoms, except in infinitely rare cases.

Sarcomatous Blood-cysts, or Hæmatomata.—Tumours have been frequently described under the name of "blood-cysts," of which the most characteristic feature is the presence of a large collection of fluid or partly coagulated blood in a cyst, the walls of which are imperfectly defined. If the blood be evacuated by puncture or incision, free hæmorrhage, difficult to control, or, at least, speedy re-accumulation of the fluid, is the only result. If seated on a limb, free excision of the cyst and its contents, or amputation, was justly looked upon as the only mode of treatment holding out any prospect of success. The nature of these tumours was not well understood; it has, however, recently been shown that in all probability they are, in the great majority of cases, soft sarcomata, broken down by hæmorrhage into their structure. The walls of these cysts are formed of a thin layer of sarcoma-tissue, either of the round or spindle-celled variety. A very interesting case

of this kind came under my care in University College Hospital in 1874. A healthy man, aged 40, had noticed, for about nine months, a soft swelling on the upper and outer part of the leg, which he attributed to a strain. It fluctuated distinctly ; and when I first saw it, a dark red fluid was oozing from two discoloured points. It was altogether about three inches in diameter, and of a dark purple colour. It had previously to admission been treated, first by the passage of a seton, and secondly, by being laid open and dressed from the bottom; which latter treatment had been repeated twice. On both occasions it was reported that nothing but blood escaped. I laid the tumour freely open, and turned out a large quantity of what was apparently ordinary blood-clot and then dissected away the cyst-wall. The supposed blood-clot was found, on microscopic examination, to be composed of a mixture of the cells of a round and spindle-celled sarcoma, with coagulated blood (Fig. 396). The wall of the cyst was found to be composed of pure sarcomatous tissue. The growth recurred before the wound was completely closed, and amputation at the knee-joint was performed, the patient making a good recovery.

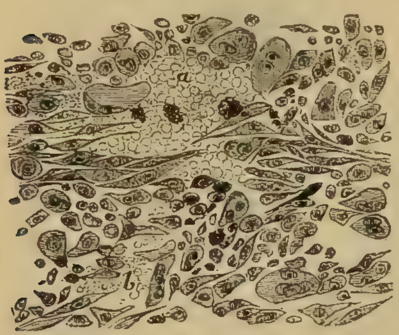


Fig. 396.—Mixed Round and Spindle-celled Sarcoma, into which Hæmorrhage has taken place (188 diam.).
a. Recent Hæmorrhage.
b. Blood-corpuscles becoming granular.

Mixed Sarcomata.—Tumours are frequently seen which combine in themselves structures properly belonging to two or more distinct forms of growth. Several of these have been already mentioned. Thus the growths standing on the doubtful line between small spindle-celled sarcoma and fibroma, are spoken of as *fibro-sarcomata.* In very rare cases some of the cells of a sarcoma may develope into true fat-cells ; we have then the *lipo-sarcoma.* Spindle-celled or small round-celled tissue is not unfrequently associated with cartilaginous tumours, forming the *chondro-sarcoma.* Occasionally large tracts of a tumour, the chief part of which is purely sarcomatous, may undergo mucous softening, and the cells may be more or less stellate or branched, as in a myxoma, and we have then the *myxo-sarcoma.* As before stated, the tissue between the acini of an adenoma may present exactly the structure of a spindle-celled or even round-celled sarcoma ; these tumours are then sometimes called *adeno-sarcomata.* Lastly, the stroma of a cancer may be composed of cells like those of a large spindle-celled sarcoma. In tumours which are purely sarcomatous it is, moreover, very common to find a mixture of the various kinds of cells which have been described as characterizing the different varieties mentioned in the preceding pages.

V. TUMOURS COMPOSED OF CELLS OF AN EPITHELIAL TYPE ARRANGED IN SPACES IN A STROMA CONSISTING OF MORE OR LESS PERFECTLY DEVELOPED FIBROUS TISSUE.

The members of this group constitute the *cancers* or *carcinomata*, and are uniformly malignant in their progress.

Cancer, Carcinoma.—Before proceeding to the individual growths forming this class, it will be desirable to say a few words upon the subject of cancer

generally.* The term has been very vaguely applied, the older pathologists, placing under this class all growths which presented a malignant aspect, intense rapidity of growth or recurrence after removal; thus all malignant sarcomata were formerly considered to be cancers. All statistics and general statements with regard to "cancer" which date back beyond 1870 must therefore be taken to refer to malignant tumours in general and not to what we now recognize as true cancers.

Although the various forms of cancer differ greatly from each other in structure, they all possess certain features in common. The essential element of every cancer is an exuberant growth of epithelium. Every exuberant growth of epithelium is not, however, a cancer. The distinguishing feature of carcinoma is that the epithelium no longer merely covers a surface or lines the acinus of a gland as in its normal state, but forces its way into deeper structures or surrounding parts. The advancing cells form bud-like processes or columns which communicate with each other by lateral branches. At the growing edge of any cancer these processes of cells can be seen advancing into the spaces of the tissue into which the growth is spreading. The pressure of the new growth seems to irritate the surrounding tissues to such a degree that they become infiltrated with small round cells. These are generally believed to be migrating white corpuscles, but it is not improbable that they may in part arise from multiplication of the cells of the connective tissue. In some forms of cancer in which the epithelial cells are small and rounded, it is not always easy to distinguish the young epithelium from the surrounding small round cells, and thus there has been much diversity of opinion as to the histological origin of cancer; but in other varieties, as the squamous epithelioma, the different forms of cells are easily recognized, and in these almost all are agreed that the cancer-cells arise from the pre-existing epithelium. If we examine a portion of a cancerous tumour, in which the structure is fully developed, we find that the original tissues of the part which has been invaded by the growth have disappeared during the process of small round cell infiltration, and that a new connective tissue has been formed which surrounds the branching columns of epithelium cells. We have thus developed an alveolar stroma, the spaces of which are filled with cells of an epithelial type, and this forms the characteristic structure of a true cancer. As in normal glands or epithelium-covered structures, the line of demarcation between the epithelium and the stroma is sharply defined; the cells lie closely in contact with each other without vessels or stroma penetrating between them. They are but loosely connected with the stroma and with one another, and in many cases are separated from each other by a very small quantity of fluid. If a thin section of a cancer be gently brushed under water with a camel's hair pencil, or shaken in a test-tube half full of water, the cells may be washed away and the stroma left. Its alveolar nature will then be distinctly apparent, and the fibrous stroma will be seen to bound spaces which by their communication form a cavernous system.

The stroma is composed of coarse fibres, sometimes almost hyaline in

* It is not my intention to enter largely into the general history of malignant diseases, as space will not admit of my doing so; I would therefore refer my readers, who wish for further information on this interesting subject, to the works of Abernethy; the papers by Lawrence; the admirable and magnificent "Illustrations of the Elementary Forms of Disease," by Sir R. Carswell; to the excellent and copious monograph by Walshe; and to Paget's philosophic Lectures on this subject. Amongst the foreign works may be mentioned "Traité des Tumeurs," by Broca; and Billroth's "Lectures on Surgical Pathology and Therapeutics."

appearance. Between the fibres are flattened or elongated cells, like ordinary connective tissue corpuscles. In some cases it is less perfectly developed, and may contain numerous small round cells, or even be composed almost entirely of spindle cells. The vessels traverse the stroma in all directions. They vary much in number and size. In some forms of cancer they are so abundant that the whole growth may pulsate; in others they are comparatively scanty. In all cancers as the growth advances the vascular supply becomes insufficient to maintain the vitality of the central parts of the tumour, and fatty degeneration, first of the cells and subsequently of the stroma, takes place. If the tumour is superficial the tissues break down, and ulceration results.

The process above described is now almost universally acknowledged to be that by which cancer arises and spreads. It was first clearly described by Thiersch and Waldeyer. It explains the fact, now well recognized by pathologists, that primary cancer never arises except in connection with pre-existing epithelium. The theories of Virchow and Classen, which attributed the origin of cancer to the connective tissue corpuscles and to migrated white corpuscles respectively, are now practically abandoned, as also is that of Köster, who believed cancer cells to be derived from the endothelium of lymph-spaces. It is believed, however, that Köster was correct in stating that the branching columns of cells do really lie in the lymph-spaces. The proliferating epithelium having burst through the wall of the acinus when the disease commences in a gland or forced its way into the deeper parts when it starts from a surface, enters the lymph-spaces and grows into them. This view is confirmed by the general arrangement of the epithelial columns, and Waldeyer believes that he has demonstrated lymphatic endothelium lying on the surface of the advancing process of epithelium. It also explains the great readiness with which cancer infects the lymphatic glands.

The cells of a cancer always more or less accurately resemble those of the normal epithelium of the part from which the primary tumour springs. Thus the cells of glandular cancers belong to the type of spheroidal or glandular epithelium; those of the skin are squamous, and those of the intestine, columnar. The cells may be larger and show a more exuberant growth than the normal epithelium, but their general characters remain the same. The old idea that there existed a peculiar specific "cancer-cell" is now completely abandoned, and it is universally recognized that no certain opinion can be pronounced as to the cancerous nature of a tumour without a careful examination, not of the cells only, but of the stroma, and of the relation of the cells to the stroma. The cells of all cancers are prone to early fatty degeneration. In some forms they undergo a colloid change.

Varieties of Cancer.—Cancers are classified primarily according to the variety of epithelium that enters into their composition, and certain subdivisions are made according to the modifications in the stroma or in the mode of growth of the tumour. The following classification is that usually adopted:—

1. Cancers, the cells of which are derived from glandular or spheroidal epithelium. *Glandular cancer.*

a. With abundant dense stroma. *Scirrhus*, or scirrhous cancer.

b. With a small proportion of stroma forming large alveolar spaces. *Medullary, Encephaloid, or Soft Cancer.*

c. One of the above forms (*a* or *b*), with colloid degeneration of the cells. *Colloid Cancer.*

2. Cancers the cells of which are derived from squamous or stratified epithelium. *Squamous Epithelioma.*

3. Cancers the cells of which are derived from columnar epithelium. *Columnar epithelioma;* sometimes called also *Adenoid Cancer.*

The special clinical and pathological features of the various forms will be considered after the general facts which are common to all varieties.

Secondary Cancerous Growths.—The most marked feature of all cancers is their tendency to give rise to secondary growths of a similar nature in various parts of the body. These may occur in three situations. First, in the lymphatic glands which receive the lymph from the affected part. Secondly, in the cellular tissue in the immediate neighbourhood of the growth; and thirdly, in distant parts, especially in internal organs. These secondary growths always resemble the primary growth in structure. The secondary tumours from a glandular cancer contain glandular epithelium cells, those from a squamous epithelioma, squamous epithelium, and those from a columnar epithelioma, columnar epithelium. The epithelium may be slightly modified from growing in a situation where it is far less exposed to surrounding pressure, or more abundantly supplied with blood, but its general characters always remain the same. In like manner the stroma of the secondary growth may be less abundant than that of the primary, and thus cause some modification in the consistence of the tumour; but the broad fact remains—that the secondary tumours are of the same structure as the primary.

The mode of origin of the secondary tumours has given rise to much diversity of opinion. The view now usually accepted is that the secondary growths arise from the entrance of the cells of the cancer into the lymphatics or blood-vessels, by which they are carried to distant parts, and there lodging develop into tumours of the same nature as that from which they sprung. According to this theory, the cells of the new tumour are the descendants of the original cell which started from the primary growth. Simon, Creighton, and others believe that the new growth arises from the cells of the part in which the cancer-cell has lodged, and upon which it exerts what they term a "spermatic influence." Whether this be so or not it is impossible to determine with certainty. The view of the direct transference of the cells of the tumour to different parts of the body is known as the *implantation theory.* Opposed to it is the *infection* theory, according to which the system is poisoned by the juices of the primary growth. There is yet another theory maintained by those who believe cancer to be a primary "disease of the blood," of which the tumour is merely the local manifestation. Those who hold this view believe that the secondary growths are merely a further effect of the constitutional condition from which primary growth originated. Thus Paget is of opinion that in some cases, in which a rapid multiplication of cancers takes place, this may arise from an increase in the cancerous diathesis or morbid condition of the blood. But he believes that in most of these cases there has been a conveyance of cancerous material by the blood, in the form of embola, which have determined the local seat of the secondary growth; and he supports this view by referring to the analogy pointed out by Walshe as existing between the secondary deposits in cancer and the secondary abscesses in pyæmia; the liver and lungs in both cases being principally affected. He, however, thinks that it is not necessary to suppose that entire cancer-cells are thus transferred; cancer-juice, or minute fragments

of cancer-plasma, may be as efficient as entire cells. Virchow considers that the fact that the secondary deposit does not necessarily occur in the organ through which the blood must first pass, militates against the theory that cancer-cells are carried onward by the circulation, and become impacted in the smaller vessels of the part, in the manner of emboli. He inclines to the belief that the cancerous juices are absorbed and enter the circulation either directly by the veins or indirectly through the lymphatics, and that they give rise to changes in the nutrition of certain parts, leading to the development of cancerous growths.

In favour of the simple transplantation theory is the important fact that in the secondary growths epithelium arises in situations in which it is not normally present as in the lymphatic glands and bones and when the growth is situated in an organ in which epithelium is normally present, as in the liver or kidney, the cells of the new growth are not those natural to the organ, but confined to those of the primary cancer. Thus Moxon and many others have recorded cases in which the tumours in the liver secondary to cancer of the great intestine have shown distinct evidence of their origin in being composed of a structure resembling in appearance the crypts of Lieberkühn. That the cells may pass along the lymphatics is sometimes shown by finding lymphatic vessels distended with nodules of cancerous growth. It is difficult to imagine juice or granular *débris* which could cause the development of glandular epithelium in bone or columnar epithelium in the liver.

The fact that the secondary growths do not invariably arise directly in the course of the lymph or blood-stream, as for instance when secondary tumours are found in the liver or bones and not in the lung, may be explained by supposing that the transplanted cells do not grow with equal facility in all structures. The experiments of transplantation of one kind of tissue into another, as periosteum into the subcutaneous tissue, have shown that although it may grow for a time, it eventually perishes and is absorbed. In the same way, up to the present time, no success has been met with in the efforts to transplant cancer from a diseased animal to a healthy one of the same species. This power shown by a tissue of resisting the growth of a foreign structure within it is called by Cohnheim *the physiological power of resistance of the tissues.* Cohnheim therefore explains the failure in the attempts to inoculate cancer by supposing that the physiological resistance of the tissues to the growth of the foreign structure is in the normal state sufficient to prevent the development of the transplanted cells. He assumes that in cancerous subjects the resisting power is diminished, possibly in consequence of the poisoning of the system from the primary growth, and that this plays as important part in the development of secondary growth as the transplantation of cells. Against the theory that the secondary growths are the result of the same constitutional condition which gave rise to the primary growth it may be urged that, if this were the case, the secondary tumours should appear in the favourite seats of the primary growth, and that each tissue should produce the form of cancer natural to itself, which, as we have seen, is the reverse of that which really occurs.

Some forms of cancer show a much greater power of reproduction than others. Thus glandular cancers recur rapidly throughout the body, while epithelioma seldom infects beyond the nearest lymphatic glands. Whatever may be the exact mode of formation of the secondary growths, the

balance of evidence may be said to be greatly in favour of some form of the transplantation theory, and therefore we may hope that, if the tumour could be removed sufficiently early, dissemination of the disease might be prevented. The theories here put forward with regard to cancer apply equally to the malignant sarcomata.

General Clinical History of Cancer.—All forms of cancer present numerous points of resemblance in their progress. When once formed, the tumour continues progressively to increase in size, with a degree of rapidity, and to an extent, that vary according to its kind. Its growth is usually accompanied by pain, varying with the situation of the tumour and its variety. When the tumour has reached a certain size, the process of decay commences in the central parts, while growth continues at the circumference. The mass softens at some point, the skin covering which becomes duskily inflamed and ulcerated, and an irregular sloughy aperture forms, through which the *débris* of the mass are eliminated in an ichorous or sanious fluid, having often a peculiar fetid smell. The ulcer then rather rapidly increases, with everted edges, a hard and knobby, or soft and fungating surface, and the discharge of a dark fluid, often attended by hæmorrhage, and occasionally with sloughing of portions of the mass at an early period. Sometimes coincidently with the implication and ulceration of the skin, secondary growth takes place in the lymphatic glands, and most commonly with the supervention of the constitutional cachexy. The pain in the primary tumour is usually more severe during ulceration, but secondary tumours in internal organs are often painless. The cachexy may possibly be due to some modification in the condition of the blood, induced by the action of the morbid growth on the economy. The exhaustion resulting from the ulceration, sloughing, and consecutive hæmorrhage, and the secondary deposits in internal organs, also commonly increases this cachectic state ; in many instances it is not marked until after the skin has become affected, and in others it does not supervene until ulceration is actually set up. In this cachexy the countenance is peculiarly pale, drawn, and sallow, so that the patient has a very anxious and care-worn look. The general surface of the body commonly acquires an earthy or yellowish tint, and not unfrequently large spots of pityriasis or chloasma make their appearance on various parts of it ; the appetite is impaired, the voice enfeebled, the muscular strength greatly diminished, and the pulse weak. The patient complains of pains in the limbs, of lassitude, and of inability for exertion ; he emaciates rapidly, and frequently suffers from the occurrence of cancerous deposits in internal organs ; and at last dies from exhaustion, induced by the conjoined effects of weakening discharges, general debility, and pain.

Causes.—The causes of cancer, as of all other diseases, may be divided into two great classes, viz. : the constitutional or predisposing, and the local or exciting.

So far as the *constitutional or predisposing* causes of this disease are concerned, it may be said that it is difficult to connect any distinct or recognizable constitutional condition with a tendency to this disease. Cancer commonly shows itself in persons apparently in perfect health, of florid complexion, robust habit of body, with every aspect of health and sign of strength.

But if we fail to recognize by outward signs a constitutional tendency to

cancer, we cannot doubt that its development is connected with a hereditary tendency, and is influenced by age.

The *hereditariness* of cancer has been established beyond a doubt. Velpeau states, as the result of his researches, that it is traceable hereditarily in one-third of the cases. Paget finds that amongst hospital patients the hereditariness amounts to about 1 in 6, but amongst private patients, whose family histories are better known, it is found to be hereditary in 1 in 3 ; thus agreeing with Velpeau's estimate.

The hereditary tendency is in some cases not only to cancer generally, but to same form of cancer. Thus, Paget records a case in which three generations were affected by uterine cancer. Sibley records an instance in which a mother and five daughters suffered from cancer of the left breast. It is not, however, by any means always so. Paget states that it is only in about one half of the cases of hereditary cancer that it is thus transmitted, and then almost exclusively in the breast and uterus. He relates one striking instance of the opposite mode of transmission. A lady died of cancer of the stomach ; one of her daughters died of cancer of the stomach, another of cancer of the breast ; and of her grandchildren, two died of cancer of the breast, two of cancer of the uterus, one of cancer of the bladder, one of "cancer of the axillary glands," one of cancer of the stomach, and one of cancer of the rectum. The hereditary tendency transmitted from parent to offspring would seem therefore to be not purely local, as in the case of a peculiar feature, a fifth finger, or the like, but to affect the whole of the epithelial tissues, the peculiar spot at which the cancer appears being dependent on local causes usually unknown. The condition is more analogous to premature baldness or greyness of the hair. Admitting the hereditary nature of cancer to the fullest extent, however, it still leaves two-thirds of the cases unaccounted for.

Age exercises a marked influence on the occurrence of cancer, both as to its frequency and its mode of growth. The statistics published before 1870 in this country, and perhaps a few years earlier in Germany, cannot be relied upon as giving a just notion of the influence of age on the occurrence of true cancer. Before that time all soft rapidly growing sarcomas were described as cancers. The malignant glioma of the eyeball, and sarcomatous tumours of the testicle and bone, being formerly classed as encephaloid cancer, that disease was said not to be uncommon in children. Now that these are excluded, all forms of cancer may be said to be almost unknown under 20. Gurlt, who possesses the patience and industry necessary for the collection of statistics to a degree rarely if ever equalled, has obtained from various sources the records of 16,600 cases of tumours of all kinds. Of these, 11,131 were cancers. In 4,769 cases of cancer, of which the age is recorded, only 0.4 per cent. occurred under the age of 20. As some of the statistics extend back to the year 1855, it is possible that even this number is in excess of the truth. In the opposite extreme of life there is no limit to the age at which cancer may occur. According to Walshe the proportion of deaths from cancer per thousand living at each age increases steadily up to 80. Gurlt shows that the absolute frequency of cancer reaches its maximum between 41 and 50, 31.68 per cent. of all cases occurring between those ages. Age influences also the liability to cancer in special organs. Thus, in extreme old age cancer of the breast is less common than in younger women, while old men are more liable to cancer of the bladder and prostate, and to epithelioma of the lip. Thus, Walshe states that proportionally to the

number living, cancer is more common in men than in women after 80. Sibley states that the average age of patients with uterine cancer is 43, and with mammary 48 years. The colloid variety rarely if ever occurs before 30. The age of the patient exerts a considerable influence on the rate of growth and malignancy of the tumour. As a rule, the younger the patient, the more rapidly does the tumour grow, the earlier does it affect the lymphatic glands, and the more widely disseminated are the secondary growths. This rule has, however, many exceptions.

Mental Emotions of a depressing character, if long-continued or frequently repeated, may possibly predispose to the occurrence of cancer. I have seen so many cases of cancer, more particularly of the abdominal organs, in individuals who have suffered much from grief, anxiety, or harass of mind for years before the development of the malignant disease, that, although the doctrine is incapable of proof, I cannot but look upon it as probable, that the cancer was the result of the antecedent long-continued mental disquietude. We know, by every-day experience, that functional derangement of the abdominal and pelvic organs of the most inveterate character may be occasioned by mental disturbance ; and it appears to me not improbable, that such functional derangement may at last lead to perversion of nutrition, terminating in malignant growth in such organs, as the uterus, the liver or the stomach, as are more readily influenced by the condition of the patient's mind.

Sex.—The influence of sex is well marked, not only in the absolute frequency of cancer, but in its occurrence in organs that are special to each sex. Cancer is absolutely far more frequently met with in women than in men, simply because cancers of the uterus and mamma constitute by far the largest proportion of these diseases, being infinitely more common than cancers of the male organs. But when we come to cancers of organs that are common to both sexes, as the tongue, the lip, the intestinal tract, &c., we shall, I think, find that they are more frequent in men than in women ; the difference, however, not being sufficient to counterbalance the preponderance in the female reproductive organs. Von Winiwarter states, that in Billroth's hospital and private practice from 1867 to 1876, 278 cases of cancer of the skin and mucous membrane of the face and mouth came under observation. Of these 226 were men, and 52 women.

The *Exciting* causes of cancer are of two kinds ; direct external violence, or long-continued irritation of a part.

A blow on, or other injury of a part, often appears to be the direct determining cause of the development of a primary cancer. Scirrhus of the mamma is commonly attributed by the sufferer to the infliction of an injury.

Long-continued irritation of a part also may cause a cancer to develop. This is a matter of every day observation in the development of cancer of the tongue from the persistent irritation of a broken or jagged tooth, or the production of cancer of the lip by the constant use of an unprotected clay-pipe. But, perhaps, the best marked instance of the production of this form of cancer, is that of the cancer of the scrotum in chimney-sweeps, developed by the irritation of the soot lodged in the rugæ—a form of disease which is now very rarely met with. Lawson attributes this to the fact that formerly soot fetched a high price, and was always sifted to free it from particles of mortar before it was sold. This sifting was hard work, and the motion of the body during the

process caused considerable friction of the scrotum against the trousers, and this, combined with the irritation of the mixed soot and perspiration, seems to have been the determining cause of the growth of the cancer. Now that soot is of little value it no longer pays to sift it, and consequently chimney-sweep's cancer has almost disappeared. It is a strong argument in favour of the theory of the local origin of cancer, that a form of the disease should cease to appear on the removal of the source of local irritation that produced it.

But local irritation is more likely to produce cancer if it be applied to a part that has already been for some time the seat of structural epithelial change. Thus, in a common wart, mole, or cicatrix, cancerous growths are very apt to develope under the influence of persistent irritation. And, as J. Hutchinson has truly observed, a cancer may in this way be "grown."

The mode in which a local injury or source of irritation produces a cancer is unknown. Does it do so by some peculiarity of local action, or by a constitutional state of a cancerous nature causing what might otherwise prove to be a simple irritation to assume a malignant form? The answer to these questions involves the whole theory of the local or constitutional origin of cancer, to which I must refer the reader. (See next page.)

It is very important to bear in mind that all tissues and organs are not equally liable to cancer. Every part of the body in which epithelium (as distinguished from endothelium) is naturally present is liable to become the seat of cancer. But it occurs more frequently in some parts than in others. In the female it is most common in the mamma and uterus; in the male epithelioma of the lips, tongue and penis is the most common form of the disease. In the alimentary canal it is most common at the narrowest parts which presumably are most exposed to mechanical injury. Thus commencing at the mouth we find the common situations of cancer are, the lips, the tongue, the fauces, the œsophagus at the back of the larynx, the cardiac orifice and the pylorus. Then follows the small intestine in which the contents are fluid and the diameter almost uniform, and here cancer is extremely rare. It is less rare at the ilio-colic valve, and becomes common in the sigmoid flexure, which is the narrowest part of the great gut and contains solid fæces. In the rectum it occurs usually where the gut is slightly narrowed as it passes through the recto-vesical fascia, and finally it is common at the anus.

The form of cancer met with in all these places is dependent on the epithelium normal to the part. As far as the cardiac orifice it assumes the form of squamous epithelioma, at the cardiac orifice it is usually one form of glandular cancer, at the pylorus and as far as the anus it is columnar epithelioma, and at the anus it is again squamous epithelioma. It has been observed that in those organs which have an intermittent functional activity, cancer is more frequent than in others, and in them it is especially apt to occur at the periods of commencing senile degeneracy.

The Geographical Distribution of Cancer is a most interesting and important element in the problem of its origin, and by a closer study of it than has hitherto been made, I believe that much light may be thrown on this.

Cancer appears to be a disease favoured by, if not actually dependent on, the aggregation of individuals under the influence of an advanced civilization. Amongst savage tribes, as amongst wild animals, it is unknown. In the great centres of civilization, as amongst domesticated animals, it abounds.

Cancer is said to be unknown in the frigid zone. The Esquimaux in the Western, and the Samoieds and other migratory tribes in the Eastern hemisphere, are equally exempt from it. Amongst the inhabitants of the torrid zone it also rarely occurs; though in the more populous parts and the seats of an older civilisation, as in India, it is not unknown. But on this and other points connected with the geographical distribution of this fell scourge, we require additional and precise information.

Cancer is certainly more common in Europe than in any other part of the civilized world. In some parts of the United States of America and in China also it appears to be of frequent occurrence, whilst in South America, in Africa (except Egypt), and in the greater part of Asia, it is not common.

Haviland has obtained very important results from the investigations of the tables of mortality of this country, with regard to the distribution of cancer in Great Britain; and his investigations appear to lead to this conclusion, that geological formation, soil, and resulting endemic conditions exercise a marked influence on the development of cancer.

Haviland finds, with regard to England, that cancer is most common in the western and north-western parts of the kingdom, including Wales; and that generally throughout the more elevated midland and southern districts it is not common. It is less frequent on the older geological formations, towards the sources of rivers, and in dry well-drained districts. He points out, on the other hand, that the sites of the great cancer-fields of England are the tertiary formations and the alluvial districts; that cancer surrounds the course of the great rivers after their full formation, when they are passing through valleys and low-lying lands liable to floods and to the consequent accumulation of alluvial deposits. These districts are also the most densely populated. Hence it may be inferred that density of population favours the production of cancer, and that wherever social organization is highly developed, there cancer becomes proportionately rife. But this view is not quite borne out by statistics. Thus we find that the development of cancer does not depend on mere population, as the mortality from cancer in Norwich and Great Yarmouth, comparatively small towns, is to that in such great centres of population as Liverpool and Manchester as 141 to 84, or nearly double; that in Philadelphia it is to that in the much larger city of New York as 15 to 7, or more than double; while in Marylebone it is very far higher than in the capital of Pennsylvania. In these conclusions we must not, however, omit to take into account the increased tendency to hereditary transmission amongst a comparatively settled population, such as that of the east of England.

Is Cancer a Disease of Constitutional or of Local Origin? This question has led to much discussion among pathologists. There are at least three distinct theories with regard to the origin of cancer. *a.* It is a blood-disease. *b.* It is purely local in its origin. *c.* If local in its origin, it can only be developed in a constitution that is fitted in some way for its formation; a fitting soil, in fact, is required for the cancer to germinate in.

We will consider these views separately; and in so doing, I may observe that it will be extremely difficult, if not impossible, to separate the two questions as to the origin and the development of cancer from one another; for, however essentially they may be distinct and separate, they blend in such a discussion as this in an almost inextricable manner.

a. That cancer is a blood-disease—a disease essentially dependent on a

morbid state of the blood—is a view that has long been entertained by many. But, in truth, this doctrine with regard to the origin of cancer has been made to include two distinct propositions ; the first being, that the blood itself is charged with the poison of cancer which is ready to burst forth or to sprout out on any part of the body on the application of the necessary local irritation or disturbance ; the second, that "blood-disease" and "constitutional disease" are synonymous and convertible terms. This latter is undoubtedly an error. It is quite possible to understand and to hold the view that the tissues of the frame are imbued with a cancerous tendency, without having recourse to the hypothesis that they derive this from the blood. The germinal membrane of the chick, as has been pointed out by Sir W. Gull, takes on changes antecedently to, and independent of, the formation of the blood. And so we may take it as possible that the tissues of the body may inherently possess morbid or cancerous proclivities, independently of the blood by which they are nourished. But if by blood-disease be meant a disease in which the blood actually contains the cancer-cell, as the blood in gout does the materies morbi of that disease—*viz.*, uric acid circulating through the body and capable of deposit in some locality favourable to the local development of the malady—this hypothesis is certainly untenable. There is no evidence whatever, histologically, that the blood of any individual is a poison-bearing fluid, and has a cancerous constitution or tendency, or that, at all events before the primary growth has developed itself, the cancer-cell, or any material capable of undergoing cancerous development, is met with in the blood. Every phenomenon that occurs in connection with cancer may be explained without having recourse to such a hypothesis as this, which has not a particle of pathological observation on which it can be based. But if the doctrine of cancer being a blood-disease is untenable in the sense in which I have here stated it, the same cannot at once be said in the way of its being primarily a constitutional affection independently of the blood.

The doctrine of the constitutional origin of cancer may be more clearly expressed in the words of Paget. "Cancers are manifestations of certain specific and morbid states of the blood ; and in them are incorporated peculiar morbid materials which accumulate in the blood, and which their growth may tend to increase." "The existence of the morbid material in the blood, whether in the rudimental or in the effective state, constitutes the general predisposition to cancer ; it is that which is by some called the predisposing cause of cancer. The morbid material is the essential constituent of the cancerous diathesis or constitution ; and when its existence produces some manifest impairment of the general health, independently of the cancerous growth, it makes the primary cancerous cachexia." For the local manifestation of this constitutional disease, the part where it is developed must be put into a favourable condition by irritation, injury, or other similar cause. The blood-disease and the local conditions may compensate each other ; thus, with an intense cancerous diathesis, tumours may be formed in such a way and in such numbers as to be apparently independent of local conditions ; while in cases where the constitutional element exists in a low degree, a long continuance of irritation may be required to bring out its local manifestations. Paget believes that by this theory of compensation the opposing views as to the local or constitutional origin of cancer may be reconciled.

b. The theory as to the local origin of cancer appears to be more generally

adopted by Surgeons. Velpeau, Billroth, De Morgan, all support or incline towards it. The arguments on which it is based may briefly be summed up as follows. They are certainly sufficient to account for all the phenomena of cancer; and many of these phenomena do not admit of explanation on any other theory.

1. Cancerous tumours spring up in individuals who have always enjoyed perfect health, and who are to all appearances perfectly well at the time of the occurrence of the disease. As in these cases there is no evidence whatever of constitutional affection of any kind, it would be a begging of the whole question to assert that the existence of the local tumour must of itself be taken as an indication of a constitutional cancerous tendency.

2. Such primary tumours are always single—no primary outbreak of multiple cancers ever occurs. Tumours may form in certain cases in rapid succession, but never simultaneously. But primary cancer does not occur at the same time at different of these seats of election—as the mamma, pylorus, and rectum, as would be the case were it constitutional.

3. Cancers are not unfrequently the result of some local injury or irritation. This is a matter of daily observation in the lip, the tongue, the female breast, and the scrotum.

4. The general health does not, in the majority of cases, suffer until some months have elapsed; when, after the lymphatics or glands have become implicated, or the neighbouring tissues invaded, but not until then, signs of cachexy set in. In many cases of cancer, especially of the mamma, the health continues excellent for many months—a year or two even after the disease has declared itself, and so long as it continues to be confined to its primary seat. It is not until after secondary deposits have occurred that the characteristic cachexy sets in.

5. If the primary tumour be removed before neighbouring parts have become contaminated, the health, if it have suffered, often improves materially.

6. All pathological evidence tends to show that the secondary growths arise directly as a consequence of the primary tumour, first, by extension by continuity of tissue; secondly, by extension along the line of the lymphatics; and thirdly, through the blood-stream, leading to growths scattered throughout the body in the same directions as the secondary abscesses in pyæmia which result from septic emboli.

7. Secondary cancers affect the form of the primary one. Thus, primary glandular cancer leads to deposit of masses of the same structure in the lungs; columnar epithelioma of the rectum to secondary growths in the liver, with identical structural peculiarities.

8. Growth is favoured by local circumstances, as warmth and moisture of cavities.

9. In some rare instances no recurrence whatever takes place after operation, the disease being eradicated from the system, which could not be the case if it were constitutional.

10. When recurrence does take place soon after an operation, it is almost invariably either in the cicatrix or its immediate neighbourhood, or in the nearest lymphatic glands, owing to cancer-cells which had been widely disseminated, escaping removal, and subsequently developing into new tumours. Were the disease constitutional, recurrence would be as likely to take place in other parts, especially in symmetrical parts.

11. We observe the same tendency to recurrence after removal, and even to secondary growths in distant organs, in other tumours which are incontestably local at first, such as the sarcomata and the enchondromata, and which only become general in certain constitutions under special conditions in their more advanced stages, and in a secondary manner.

The theory of the local origin of cancer is undoubtedly a very captivating one. It explains in the readiest and the simplest way possible most of the phenomena of the disease. But it is a doubt with many, if it be competent to give a satisfactory solution of all.

There are at least four conditions that may be supposed to militate against the theory of the primary localization of cancer, and which have been, or may be, adduced as evidences of the constitutional origin of the disease.

These are—1. The almost absolute certainty of the recurrence of the disease after the removal of the primary growth ;

2. The frequent hereditariness of the disease ;

3. The varying degrees of rapidity with which cancers run their course and the different degrees of virulence they affect in different individuals ; and

4. The geographical distribution of cancer.

Let us briefly examine those conditions, which have mainly been relied on in support of its constitutional origin.

1. As to the *liability to recurrence after removal*, as will be more fully stated when we come to speak of the operation for cancer, there can be no doubt. But in truth this argument can have but little weight, when we consider the rapid tendency to diffusion that has just been described as characterizing cancers above all other tumours, owing to the peculiar mode of growth already described and the relation of the cells to the lymphatics. The fact is, that the cancer-cells have already become diffused through the neighbouring structures, and may have entered the lymphatics or the blood long before the primary tumour has attained such a size as to attract attention so as to render operation possible.

If it be admitted that a cancer may commence this process of diffusion at any period after its formation as a distinct growth, it is impossible to deny that the recurrence of the disease after operation, whether local in the neighbouring areolar tissue, more distant in the lymphatic glands, or, further still in the viscera, may be due to the early transplantation of the cells, each of which has become the centre of a new growth. It would be too late to uproot the thistle after its seeds had been widely scattered abroad.

One main source of confusion, if not of error, in respect to the origin of cancer has been, that it has usually been studied in organs, such as the mamma, in which its early origin cannot be discovered. In such a situation a tumour must attain the size of a nut, at the least, before it is diagnosed or even detected. How many months may it have required for the first small group of cells to have led to the development of such a mass as this, and how widely the local contamination and general infection may have spread, before such a size even as this is attained by the primary tumour.

2. The next point is the *hereditariness* of cancer. As has already been stated, this is undoubted. But a hereditary tendency to a disease must not be confounded with a constitutional disposition to it. It is a fatal error in etiology to confound hereditariness with constitutionalism. Hereditariness may be local as well as constitutional. The hereditary transmission of a

particular feature from parent to offspring cannot be considered a proof of a constitutional tendency. So also the hereditary transmission of a malformation, as of supernumerary fingers or of exostoses, is certainly purely local. But diseases may also be transmitted through descent without being in any way constitutional. Tumours that are not cancers are hereditary, as warts, lipomata, enchondromata, &c. ; sebaceous cysts of the scalp are strongly hereditary, and yet there can be no pretence that these are in any way constitutional or blood-diseases. These are instances of hereditary local diseases that are not congenital, but develop after the body has reached maturity ; just, indeed, as a cancer does. We do not look upon these conditions as constitutional—dependent on some conditions of the blood, merely because they are transmitted from parent to offspring. All that we can at present assume is, that it is probable that in some cases there is a predisposition of unknown nature, hereditarily transmissible, which may tend to the development of cancer without the action of a known local exciting cause ; and this hereditary tendency may be local, as in a certain tissue, or in a particular organ which is the usual seat of election of cancer, as the mamma, the testis, or the pylorus.

3. The *greater virulence* affected by cancers in some individuals than in others, and the *varying degrees of rapidity* with which they run their course, would undoubtedly lead to one of two inferences ; either that the primary cancer is more active, has greater inherent vitality, or that the constitution in which it occurs is more favourable to its development.

The varying virulence of a cancer depends much more upon its anatomical structure than on any constitutional condition of the patient. All glandular cancers are more malignant than squamous or columnar epitheliomas ; yet those who hold the theory that cancer is a blood-disease, maintain that it is a mere accident where the primary tumour arises, and consequently what form it assumes.

The locality in which the cancer develops has also much to do with the rapidity with which the glands are affected. H. Arnott pointed out that the softer, the more vascular, and the more movable the primary seat of the tumour is, the more rapidly do the secondary growths appear. Thus an epithelioma of the tongue always affects the glands very early, while with a similar growth on the skin of the leg the patient may escape glandular affection for many months.

The fearful rapidity of growth and virulence shown by a cancer of the mamma during pregnancy consequent upon the physiological increase of the supply of blood to the gland is another example of a local condition affecting the malignancy of the growth. Moreover, if great rapidity of the growth were due to the presence of the poison in the blood in greater amount than usual, we should expect to find the development of the tumour most rapid in those who showed the most marked cachexia, whereas the reverse is usually the case. The younger the patient and the better the general health at the time of invasion, as a rule the more malignant will be the course of the disease. Still it is highly probable that there is a tendency in the tissues of certain individuals to favour the development of these cancer-growths, originating primarily in some local irritation, whether this be traumatic or functional. Such a constitutional state, whether hereditary or acquired, is necessary to constitute a fitting soil for the cancerous element, in which to form and to

develop. The stronger the tendency the more readily will cancer grow in such individuals, and the more rapid and vigorous will be the growth. This constitutional state does not develop a local cancer; it simply favours its development.

4. The *geographical distribution* has been already considered at p. 1014. It cannot be said that this has much bearing upon the question. The influences resulting from race, soil, climate, &c., are concerned in the development of many local diseases, such as simple bronchocele, elephantiasis of the scrotum, fibroma in the ears of negroes and the like, none of which are supposed to be due to the presence of a morbid material in the blood. We have no definite knowledge to guide us to any conclusion with regard to the effect of these influences on the development of cancer; and, in its absence, it is just as easy to suppose that these causes act locally on certain glands or epithelial surfaces as to imagine that they give rise to the development of some unknown poison in the blood to which the origin of the cancerous tumour is due.

There are two points in connection with the structure of cancer that deserve careful study, in reference to the question of local origin. The first is the abundant blood-supply that a cancerous tumour invariably demands and obtains: the second is its mode of infiltrating the surrounding tissues.

Each of them has an important bearing on its diffusion.

1. The much larger *blood-supply* that is furnished to a cancerous growth than is sent to any other kind of tumour, except the soft sarcomata, is well known to all practical Surgeons. A scirrhus of the mamma, not larger than a pigeon's egg, will receive a far larger vascular supply than an adenoma as large as a cocoa-nut, the number of arteries requiring ligature after an operation in one case being greatly in excess of those that spout in the other. This abundant vascular supply is noticeable in the removal of the smallest cancers, but increases with the size of the tumour.

The tumour itself is not usually very vascular, though some cancers, as the encephaloid, are so abundantly so as to present little else than a congeries of vessels, and to possess active pulsation and bruit; but the vascularization is in the neighbouring and surrounding parts, in the midst of which it lies. This greatly increased vascularity of the neighbouring tissues is most probably due to the irritation caused by the peculiar mode of growth of a cancer. Simple tumours, such as lipomata, enchondromata, exostoses, &c., merely displace the surrounding structures slowly by their pressure as they increase in size, and the tissues thus have time gradually to accommodate themselves to their altered position, and suffer but little till the bulk of the tumour becomes very considerable. A cancerous tumour, on the other hand, sends out processes of cells which grow rapidly and force themselves into the interstices of the surrounding parts, and it thus exerts from the first a direct pressure on the tissues it is invading. The microscopic appearances of the tissues surrounding the advancing processes of cells, are in fact identical with those of inflammation. The vessels are dilated and full of blood, and the normal structures are concealed by an abundant small cell infiltration before which the original tissues disappear as in the process of ulceration. The quantity of lymph returning from the hyperæmic tissues will necessarily be greatly increased in quantity, and the lymph-spaces and lymphatic vessels will be dilated, and thus the dissemination of the cells of the cancer will be greatly facilitated should any of them become disengaged from the general mass and enter the lymph-stream.

2. The second important point in connection with the structure of a cancerous tumour is the *absence of an enveloping capsule;* unlike almost every simple tumour, it is not in any way encysted or encapsuled. As before pointed out, there is every reason to believe that the processes of epithelial cells which force their way into the surrounding structures are actually lying in spaces directly communicating with the lymphatic vessels. There is no barrier between them and the tissues they are invading, nothing to limit their extending into them and destroying them.

What circumstances or conjunction of circumstances can possibly favour more highly the diffusion throughout the neighbouring tissues and of the whole system of a primary growth, than such a mode of growth stimulated by active hyperæmia of the surrounding structures?

This invasion of the lymph-spaces may lead to a much earlier contamination of tissues and of the system than is generally supposed. We do not know, and there is in the present state of science no possibility of ascertaining, how soon after its first formation, whilst still a microscopical nodule, a cancerous tumour may begin to shed its cells into neighbouring areolar spaces or lymphatics. From the very first day of its formation—from the very first of the multiplication of its cells—the highly organized but fatal cells may have started on their travels into areolar spaces, carried on by the increased lymph-stream, but capable of self-support whenever arrested, and in their new *habitat* developing into fresh cancerous centres capable of the same process of multiplication and of local infection, which may be indefinitely extended; capable also, probably, of entry into the vessels, of being carried through them to distant organs, and deposited in them, like pyæmic embola, forming centres of new growth in the lungs or liver.

It is this early tendency of cancer to dissemination that leads to the supposition of its being constitutional. For the system may become permeated by cells shed from the parent primary tumour, before this has attained sufficient size to attract serious attention, if, indeed, it has been observed at all.

Having thus described the cancer in general, we are in a position to consider more in detail the special varieties.

1. Glandular Cancers, or cancers the cells of which belong to the type of glandular or spheroidal epithelium, may arise as primary tumours in any parts in which glandular epithelium is normally present. They may thus arise in the breast, the salivary glands, the liver, pancreas, prostate, kidney, and many other parts. They are subdivided into two chief varieties:—1. Scirrhus or hard cancer, in which the stroma is very abundant and firm. 2. Encephaloid or soft cancer, in which the stroma is scanty and the cells abundant. These two forms merge insensibly into each other, and no sharp distinction can be drawn between them. A tumour that one Surgeon would call a rapidly growing scirrhus of the breast, another might describe as encephaloid. A third variety of glandular cancer arises from colloid degeneration of the cells of either scirrhus or encephaloid, and this is known as colloid cancer, which will be described separately.

The glandular cancers yield on scraping or pressure a milky fluid, termed the *Cancer-juice*, in which cells and granules are found in varying proportions. The granules are mostly fatty, and are the result of fatty degeneration of the cells of the tumour. This milky juice, it must be observed, is not absolutely characteristic of cancer. It is yielded by the lymphadenomata and by all the

sarcomata, provided that at least twenty-four hours elapse after their removal before they are examined and that decomposition has commenced. The *cells* (Fig. 397) are extremely variable in shape and size. They may be round, caudate, and even fusiform. Many varieties of form are usually found in the same tumour, but occasionally great uniformity prevails. The size may vary from $\frac{1}{2500}$ inch to $\frac{1}{800}$ inch. The nuclei are oval and highly refracting, often placed eccentrically; they are of considerable size and frequently double, while in some cases five or six may be found in the same cell. They contain bright shining nucleoli. The size of the cells is not indicative of the variety of the cancer. Thus, in some scirrhous tumours the cells may be small, and in others large, and the same may be said of encephaloid. The distinction between scirrhus and encephaloid is made not by the size of the cells, but by the relative proportions of cells and stroma in the mass. All cancer-cells are prone to early degeneration, usually becoming filled with fat-granules, and ultimately breaking down and in great part disappearing, so that what was once a considerable mass of cells may be represented by a few granules. This is most marked in scirrhus.

Fig. 397.
A. Cells from a large Encephaloid of the Breast.
B. Cells from Scirrhus of the Breast.
a. Stained. *b.* Unstained.
(454 diam.).

The *stroma* in glandular cancers is almost invariably fibrous, but in the softer forms it may be composed partly of spindle-cells. The alveolar arrangement is always clearly marked. The cells lie loosely in the spaces often separated from each other by a small quantity of fluid. This fluid, with the cells, forms the "cancer-juice." In the degenerating parts of the growth the stroma frequently contains numerous fat granules, and in very rare cases patches of calcification are met with. The *blood-vessels* are usually abundant, especially in the softer forms. In some rare instances they show curious bud-like processes and dilatations projecting from their walls into the alveolar spaces of the tumour. These may give way and distend the alveoli with blood, thus forming small rounded collections of blood dotted through the growth. The unaided eye of the experienced Surgeon may in many cases recognize a cancer without difficulty, but in every case the tumour should be examined microscopically in order to determine without a doubt what its true nature is.

Scirrhus.—The scirrhous or hard cancer is met with more commonly in the female breast than in all other parts of the body put together, and the cases that come under the care of the Surgeons are almost always exclusively in that situation. Thus of cases of scirrhus admitted in the surgical wards of University College Hospital during the ten years 1871 to 1880, 113 were situated in the female breast, 1 in the male breast, 4 in the skin near the female breast, 1 in the kidney, and 3 in the prostate. Nine other cases were admitted as "scirrhus of the rectum," and two as "scirrhus of the sigmoid flexure," but these were not submitted to micro-

scopical examination, and were most probably columnar epitheliomata. Scirrhus is met with also in the stomach and pancreas, and a soft form—between the hard and soft cancer, and consequently sometimes called scirrho-encephaloid—is the ordinary primary cancer of the liver. Secondary scirrhus may occur in almost any part of the body, but the most common situations are the lymphatic glands, liver, lungs, kidneys, and bones.

Scirrhus occurs in two forms; either as a circumscribed mass, or infiltrated in the tissue of an organ. In either case it forms a hard, craggy, incompressible, and nodulated tumour, at first movable and unconnected with the skin, but soon acquiring deep-seated attachments, and implicating the integument. It grows slowly, seldom attaining a larger size than an orange. At times it is painless, at others painful, generally aching, sometimes with much radiating and shooting pain through it. These sensations vary according to the part affected, and to the sensibility of the individual; the pains are especially severe after the tumour has been handled, and at night are of a lancinating, neuralgic character. The tumour may thus continue in a chronic state for a considerable length of time, slowly increasing, gradually extending its deeper prolongations, and implicating the more superficial parts. In some cases, more particularly in elderly people, scirrhus gives rise to atrophy of the organ in which it is seated, causing wrinkling and puckering of the surrounding skin, which becomes adherent to the tumour; and the cancer may thus continue in a very chronic state.

The ulceration takes place usually by the skin becoming adherent at one point to the tumour, either by dimpling in, being as it were drawn down towards it, or else by being pushed forwards, stretched, and implicated in one of its more prominent masses; it then becomes dusky and livid red, somewhat glazed, and covered by a fine vascular net-work. Softening occurs at one point, where a crack or fissure forms; a clear drop of gummy fluid exudes from this, and dries in a small scab upon the surface; this is followed by a somewhat bloody discharge of a thick and glutinous character; and the small patch of skin from which it issues, becoming undermined, speedily sloughs away, leaving a circular ulcer. This gradually enlarges, becoming ragged and sloughy, with craggy everted edges, having irregular masses arising from its surface, and discharging a fetid sanious pus. The pain increases greatly; and, the lymphatic glands becoming involved, cachexy is fully developed, and the patient is destroyed by it or by the secondary visceral deposits. In old people, ulceration of scirrhous cancers often assumes an extremely chronic character, the growth in them not being endued with the same vitality as in the young. The ulcer in these cases is flat, sloughy, of a greyish-green colour, hard and rugged, with puckered edges, and much wrinkling of the surrounding skin, and exhaling the usual fetid odour. In younger persons, and especially in stout women with florid complexions, the disease usually makes rapid progress. So also, if inflammation be accidentally set up in the neighbouring tissues, cancerous infiltration rapidly takes place in them. Occasionally, but very rarely, scirrhous masses slough out, leaving a large ragged cavity, which may even cicatrize; and thus a spontaneous cure has been said to occur. The cancerous infiltration extends to a considerable distance around the tumour into integument which to the naked eye appears quite healthy. In such tissue, however, the microscope may reveal unequivocal evidence of the existence of cancer-cells diffused through it. Wherever the

small-celled infiltration can be recognized, which surrounds a cancerous growth like a halo, and gradually shades off in the surrounding healthy textures, the tissues must be regarded as infected. It is of great importance in determining the question of operation to bear this in mind, and not to act on the supposition of the tumour being abruptly defined.

The secondary growths in scirrhous cancer form first in the lymphatic glands in almost every case ; later on they may occur in the liver, lungs, bones, and other parts. In the lungs and liver they are frequently much softer than the primary growth, so that in some cases they might be more properly termed encephaloid than scirrhous. In the lymphatic glands they are often almost as firm as the original tumour.

Structure.—On cutting into a scirrhous tumour with the scalpel, it usually creaks somewhat as it is divided, and presents a whitish or bluish-white glistening surface, intersected by white bands, which apparently consist partly of new structure, and partly of included areolar tissue. This section has not inaptly been compared to the appearance presented by a cut through a turnip or an unripe pear.

A curious feature about scirrhous cancer, in which it differs from almost all other tumours, is that it becomes cup-shaped on section. This seems to be due to the fact that in most scirrhous tumours a kind of process of cicatrization takes place in the central parts, while the peripheral parts are still grow-

Fig. 398.—Scirrhus of Breast (188 diam.) The communication of the alveolar spaces between one another and the continuity of the contained masses of cells is well shown. The contour of the individual cells is seldom definite, and the nucleoli, as a rule, are not seen.

ing. The cells undergo fatty degeneration and break up. The greater part of the products of degeneration are absorbed, and only a narrow streak of granules may be left to represent a once large accumulation of cells. It is this shrinking of the growth that drags in the nipple in scirrhus of the breast, and perhaps it is the evident state of tension in which the tumour is, that gives rise to the peculiar pain of scirrhus in general. On examining a scirrhous cancer microscopically (Figs. 398, 399), it will be found to be surrounded everywhere by a zone of small round cells infiltrating the surrounding parts, penetrating between fat-cells or muscular fibres, and extending along bands of connective tissue. A little nearer the centre the alveolar arrangement becomes apparent, and groups of rounded or irregular cells, with large oval nuclei, are

found imbedded in spaces in a stroma of coarse fibrous tissue. These spaces communicate with each other like those of a sponge. The stroma and cells at this part usually form about equal bulks of the growth. The stroma shows signs of active growth, having spindle-cells scattered here and there through it, sometimes in abundance. A little nearer the centre we find that the stroma has become more dense, the spindle-cells being replaced by elongated tailed cells, with scarcely any protoplasm around the nucleus. The cells of the cancer are here beginning to degenerate, the nuclei becoming hidden by clouds of fat-granules, and a similar change may also be apparent in the stroma. Towards the centre the fatty cells disappear, and a few granules only mark where they were ; the stroma becomes dense and hard, and even the nuclei before mentioned are difficult to recognize. The above is a description of the ordinary scirrhus of moderately slow growth. In more vigorously growing specimens the degeneration is delayed, the cicatrization is less perfect, and the proportion of the bulk occupied by the cells is increased.

Fig. 399.—Scirrhus of Breast (188 diam.). Much cicatrized; the stroma bears a large proportion to the cells, which are small and granular: in a fully cicatrized specimen there would be similar alveolar spaces containing only granular débris

It is not always easy to determine the exact mode of growth in scirrhous cancer, as the young spheroidal epithelium-cells closely resemble the small round cells infiltrating the tissues at the growing margin. In the softer and more diffused forms, it is often possible, however, to observe the earliest changes in the acini. It will then be seen that the morbid process does not start from a single acinus. Many acini lying near each other may show various stages of overgrowth of the epithelium. At first the new cells are contained within the distended membrana propria of the acinus, but as the process advances, they burst beyond its limits, and penetrate amongst the surrounding tissues. In the harder tumours of slower growth this often cannot be recognized, as the area of the gland affected is smaller, and by the time it comes under observation the acini have disappeared, and columns of cells only are found extending into the surrounding tissues.

Encephaloid.—As before stated, this is not separable from scirrhus. The greater part of the tumours which were formerly classed as encephaloid cancers are now included under the sarcomata. A glandular cancer growing with such rapidity, and of such softness of structure, as to merit the name of encephaloid is in fact a rare occurrence in surgical practice. During the ten years 1871 to 1880, there were admitted under the care of the Surgeons of University College Hospital only eight cases which were classed as encephaloid cancer. Five of those were in the breast, two in the testicle, and one was believed to have originated in the tonsil or the glands in its neighbourhood. Encephaloid cancer, like scirrhus, arises only in structures containing glandular or spheroidal epithelium. It commences as a tumour, which though occasionally somewhat

hard, is usually from the first, or at all events soon becomes, soft and elastic, being more or less lobulated, growing rapidly, and having an elastic and at last a semi-fluctuating feel. The skin covering it is usually at first pale and loose, with a large net-work of dilated veins spreading over it. In some cases, however, at a very early period, a species of inflammatory œdema occurs in the integuments covering rapidly growing encephaloid tumours. As the tumour enlarges, the skin becomes adherent, discoloured, of a purple-brown tint, and at last ulcerates at one point. When once the tumour has made its way through, and is relieved from the pressure of the fascia and integuments, the rapidity of its growth becomes fearfully increased; and a large soft fungous mass, rugged, irregular, dark-coloured, and bleeding profusely, rapidly sprouts forth, constituting the affection to which Hey gave the appropriate term of *fungus hæmatodes:* when this condition has been reached, death rapidly ensues from exhaustion and hæmorrhage. Pulsation has been met with in particular forms of very vascular encephaloid; in these cases also a loud bruit, synchronous with the pulsation and the heart's action, has been detected, and may be heard on the application of a stethoscope. These symptoms are, however, far more commonly met with in soft small round-celled sarcomata of bone, in which the pulsation may be so marked that the disease may, unless care be taken, be confounded with aneurism.

The constitutional cachexy in encephaloid occurs early and is well marked, and secondary growths speedily make their appearance in the lymphatic glands and viscera.

Structure.—After removal, the tumour is found to be very vascular, displaying on injection a close net-work of vessels. On a section being made, it

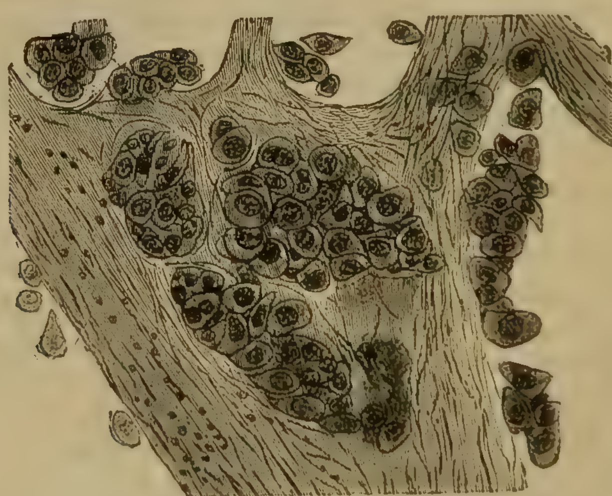


Fig. 400.—Encephaloid of Breast (188 diam.). The large-celled variety. Attention is directed to the much larger spaces in this than in Scirrhus.

commonly presents a soft pulpy white mass, closely resembling cerebral substance, stained and blotched with bloody patches, varying in colour from a bright red to a maroon-brown, this being dependent on blood that has been infiltrated into its substance. In other cases, its section has been compared to that of a raw potato, or a piece of boiled udder. On microscopic examination, it will be found to present a structure essentially similar to that of scirrhus, that is to say, an alveolar stroma enclosing groups of free cells of an epithelial

type. The cells may in some cases be larger, but are often smaller than those usually seen in scirrhus (Fig. 400). They assume the same irregular forms, and have each one or more highly refracting nuclei and nucleoli. The proportion of the bulk of the tumour composed of cells is, however, infinitely greater in encephaloid than in scirrhus, and the vascularity of the tumour is proportionately increased. The tumour does not show the same tendency to cicatricial contraction, although fatty degeneration always occurs in the central parts.

Colloid, Gelatinous, Gelatiniform or Alveolar Cancer is a variety formed by the colloid degeneration of the cells of a glandular cancer, either of

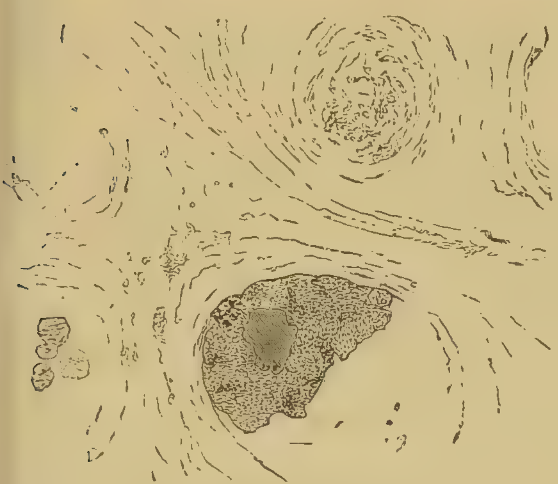


Fig. 401.—Colloid of Omentum (188 diam.). Shows the concentric rings and the granular masses which have taken the place of the cells; and at one part a few cells still retain their shape.

Fig. 402.—A. Colloid of Breast. Shows relation of cells to stroma, and the colloid material in some cases filling the cell, in others pushing the nucleus to one side or completely surrounding it. B. Isolated cells from the same tumour. C. Isolated cells from colloid of omentum. (454 diam.)

the scirrhous or encephaloid form, but most commonly the former. It may occur in distinct masses, often of a very large size, weighing many pounds, or may be infiltrated into the tissue of organs. As it is most commonly met with in the viscera of the abdomen, it does not so often fall under the observation of the Surgeon as the other varieties of cancer. Yet it is not uncommon in the breast, where I have met with it, forming a very large tumour: and there is a preparation in the University College Museum of a scirrhous breast containing colloid. Colloid cancer consists of alveolar spaces of great size, filled with a clear semi-transparent yellowish gelatinous or honey-like material, resembling indeed somewhat the structure of a honey-comb. The septa forming these spaces are distinctly fibrous and regular in their arrangement (Fig. 401). Some of the spaces are completely filled with colloid matter, others may show a few cells containing fat granules in the centre, surrounded by zones of granules, resulting from the degeneration of other cells. Cells again may be seen in the process of undergoing colloid degeneration (Fig. 402). A globule of colloid matter first appears pushing the nucleus to one side; afterwards the nucleus undergoes a similar degeneration; and finally the cell bursts and disappears, leaving behind it only a few granules. True colloid cancer is merely a degeneration of scirrhus or encephaloid. Many other tumours have been described in former times as colloid, amongst which may be mentioned many myxomata,

œdematous soft fibromata, and some glandular tumours which had undergone colloid degeneration.

Diagnosis of Glandular Cancer.—In the diagnosis of a cancer the age of the patient is an important consideration, such tumours being very rare before 30. Too much importance must not be attached to an hereditary history of cancer, or it may lead us into error. A most important sign of cancer is that the tumour forms part of the structure it is invading. It may be tolerably clearly defined in outline, but it is not separable from the surrounding tissue. It early becomes adherent to the skin when occurring in a superficial part. In the later stages the adhesion is evident, but at first it can be recognized only by pinching up the skin widely with the finger and thumb when it will be seen to dimple slightly at the part over the tumour. Both these signs, the implication of surrounding structures and the dimpling of the skin may, however, also be present in chronic inflammation with fibroid induration.

The diagnosis of the different forms of cancer is not always easily made. *Scirrhus*, when not widely infiltrating, may very readily be confounded with fibrous tumours and adenomata, or with the indurated atrophy of a part; in many of these cases, indeed, the diagnosis cannot be correctly effected until after examination by incision. In other cases, however, the rugged feel, the lancinating pains, the implication of the lymphatic glands, or the affection of the general health, will commonly serve to establish the diagnosis. When ulceration has taken place, the previous condition of the tumour, the general character of the sore, and the microscopic examination of the *dèbris*, may serve to denote its true character.

Encephaloid may be confounded with abscess, with cysts, or with erectile and sanguineous tumours, and with the various soft varieties of sarcoma; and, when pulsating, with aneurism. In these cases careful palpation, the existence of elasticity without fluctuation, and the presence of the large and tortuous veins ramifying over the surface of the mass, may establish its true character. When it is fungating, it may be confounded with the sprouting intracystic growths that sometimes spring from the interior of a cystic tumour. Here, however, the history of the case and the contamination of neighbouring lymphatics, will show the true nature of the affection.

In all cases in which there is doubt as to the nature of the growth an incision should be made into it, if it is a case fit for removal by operation, and, if necessary, a slice should be removed and examined by the naked eyes, or a scraping of it may be put under the microscope. It is much better to do this than to lose valuable time by waiting till the symptoms become more definite.

The diagnosis of a tumour as a cancer is sometimes materially obscured by the accidental development of abscess in the tissues around or above it. In such cases, the continuance of a swelling which is evidently not inflammatory, after the pus has been evacuated, may lead to a suspicion as to the true nature of the disease.

2. Squamous Epithelioma.—Squamous epithelioma, or as it has also been called epithelioma, epithelial cancer, or cancroid, was at one time considered to be distinct from true cancer. There is nothing, however, to justify such a distinction. The term epithelial cancer or epithelioma is not a good one, for as has just been pointed out, the scirrhus and encephaloid are equally

epithelial growths though arising from a different type of epithelium. Squamous epithelioma arises from any situation in which squamous epithelium is naturally present. The essential feature of the growth by which it is distinguished from a simple wart or papilloma is that the epithelium no longer merely covers the papillæ, but forces its way between them into the structures beneath.

Causes and Situation.—Epithelioma, rare in the young, is common in middle-aged or elderly people, the tendency to it increasing in proportion as age advances. In this respect it follows the course of other cancers. The hereditariness of epithelioma is not so marked as that of scirrhus, so much so that it has been doubted. I have no evidence in either way on this point. My impression is that it is not distinctly hereditary. It has been said to have been communicated by contact from the uterus of the female to the penis of the male, but this is extremely doubtful. It is certain that in the great majority of cases in which such contact has taken place no evil consequences follow.

It is frequently occasioned by the long-continued or repeated application of some source of irritation, and may thus be established in constitutions otherwise perfectly healthy. Thus, the irritation of a broken tooth upon the tongue or cheek may produce epithelioma of those parts. The scrotum in chimney-sweepers not unfrequently becomes the seat of epithelioma, in consequence of the lodgment and irritation of soot in its rugæ. Cancer of the tongue or lip is frequently attributed to the irritation caused by smoking. In some cases epithelioma arises in parts which have long suffered from an abnormal condition of the epithelium. Thus the so-called "smooth or scaly tongue" has a great tendency to terminate in cancer sometimes after the condition has lasted for ten or even twenty years. Epithelioma not unfrequently originates in old scars.

Its most common seat on muco-cutaneous surfaces. During the ten years, 1870 to 1880, 123 cases of squamous epithelioma were admitted into the surgical wards of University College Hospital. They were distributed as follows: tongue, 52; lips, 18; skin of limbs and trunk, 10; penis, 8; vulva, 7; cheeks and gums, 7; anus, 4; scars in various parts, 3; skin of face, 3; scrotum, 2; œsophagus, 2; larynx, 2; bladder, 2; soft palate, 1; and antrum, 1. During a similar period 47 cases of cancer of the uterus were admitted into the women's ward, but the hospital report does not distinguish between the different forms of the disease in these cases. Eleven cases of malignant stricture of the œsophagus, probably all epithelioma, were also admitted into the medical wards.

The selection of a particular site by epithelioma appears often to be capricious, though it is doubtless dependent on anatomical peculiarities of the part. Thus it is common in the lower lip, but so rare as scarcely to have been observed in the upper. In women it rarely attacks the lower lip, in men often; when occurring in mucous canals it chiefly affects their ends. Thus the lower end of the pharynx, the upper end of the œsophagus, and the anus are all favourite sites.

Progress.—Squamous epithelioma commences either as a small flat tubercle, or a warty growth, which rapidly ulcerates. Sometimes when it first comes under observation, it may already form an intractable fissure, or ulcer, of limited size, with hard everted edges and a foul surface. In other

cases, papillæ of great size may form on the surface of the growth before ulceration takes place. This is especially marked in cancer of the penis, in which the papillæ are sometimes half an inch in length. In the bladder epithelioma may assume a villous form. When ulceration takes place the destruction of tissue slowly spreads, implicating every structure at its circumference. Such an ulcer attacks not only the soft parts, but may extend into a neighbouring bone, penetrating deeply into its structure and eroding it. In a case under my care in University College Hospital, in which the ulceration started from a gland secondarily affected after removal of an epithelioma of the lip, the greater part of the symphysis of the jaw was destroyed and the whole floor of the mouth eaten away till the tongue hung out below on the skin of the neck. Epithelioma of the eyelids may invade and destroy the eyeball. When arising from the mucous membrane of the nose epithelioma may form one variety of the so-called malignant polypus. I have seen an epithelioma as large as a small orange, developing in this situation and passing into the orbit and to the cheek. In the mouth and uterus I have seen epitheliomata which, though commencing from the mucous membrane, have penetrated into the deeper parts and thus appeared to have originated in them. Epithelioma of the scrotum, if left unrelieved by treatment, will at last extend to and implicate the testicle.

Fig. 403.—Epithelioma of Lower Lip. Male: about 21.

After an epithelioma has lasted a certain time secondary growths appear in the nearest lymphatic glands. This takes place with varying rapidity in different cases. It was pointed out by Henry Arnott that the implication of the glands takes place most rapidly when the primary growth is situated in soft, vascular parts much exposed to movement. Thus it takes place much more readily in epithelioma of the tongue, than in the same disease of the skin of the trunk. The affected glands increase in size steadily, but not usually very rapidly, and after a time fresh glands become infected. When they reach the surface they adhere to the skin, the central parts soften and become diffluent, and finally the skin gives way and a ragged, foul cavity is exposed, discharging a thin, blood-stained fluid, which tends to become extremely offensive. Epithelioma differs from glandular cancers in one important respect ; it has but little tendency to extend beyond the lymphatic glands, and to appear in the viscera or distant parts. It does so, however, with sufficient frequency to show that the absence of secondary tumours in the viscera is not an essential feature of epithelioma.

Epithelioma most commonly occurs in otherwise healthy subjects. Even after the glands have become affected the general health may be but little impaired for some time ; but sooner or later the patient begins to lose flesh and the so-called "cancerous cachexia" makes its appearance. Epithelioma may prove fatal by the progress of the local disease, and by its external ulceration ; by its affecting a part essential to life, as the œsophagus or larynx ; by pressure of enlarged glands on important parts : and by the induction of constitutional cachexy and malnutrition with gradual exhaustion.

Structure.—On microscopic examination, a squamous epithelioma will be

found to be composed of masses of cells of the type of scaly epithelium, forming irregularly cylindrical processes communicating with each other. From the irregular course of these processes, they are cut in a variety of directions in every thin section, so that the groups of cells do not give the idea of cylinders, but rather of circular, oval, and irregular masses not in direct connection with each other. Between these cylinders is a fibrous tissue bearing abundant vessels for the nutrition of the non-vascular epithelium. This fibrous tissue is more or less infiltrated with small round cells, in proportion to the rapidity of the growth of the tumour. It will be seen from the above description that the structure of an epithelioma, although differing

Fig. 404.—Epithelioma of Anus (40 diam.). Shows the lobules extending down into the connective tissue, which is infiltrated with small round cells; four globes are seen. The isolated masses are probably cylinders cut obliquely.

in detail, is in the main similar to that of scirrhous and encephaloid cancer; that is to say, cells of an epithelial type, imbedded in spaces in a fibrous stroma, which freely communicate with each other (Fig. 404).

As in normal squamous epithelium covering a papilla of the skin, the cells next to the fibrous and vascular tissue are softer and rounder in form than those of greater age. In the centre of the terminal portion of a cylinder of cells or in a branching process from it, the epithelium often becomes flattened by pressure, and arranged circularly so as to form a globe (epithelial nest, epithelial pearl). These nest-like formations are produced, according to Virchow, by the remarkable tendency to endogenous cell-growth exhibited by some of the central cells, and the development of large "brood-spaces" within them. The pressure produced by this formation of brood-spaces, and the endogenous cell-growth accompanying it, causes the marginal cells to become flattened and to take on a concentric arrangement. Possibly these globes may be formed in both ways; but the appearance usually presented by them rather

suggests the former than the latter process, as the central parts are most frequently dry and hard, and present no signs of active growth. Similar globes are not unfrequently formed in simple warty growths, and must therefore not be considered diagnostic of epithelioma. The fully formed cells often present beautifully serrated edges, the serrations of one interdigitating with those of its neighbours. This is well shown in the accompanying drawing (Fig. 405), taken from a small epithelioma of the anus which I removed in University College Hospital. The individual cells of an epithelioma, as obtained by scraping, differ but little from the healthy scaly epithelium that may be got from the mucous membrane of the cheek or lip. They are often larger, and sometimes contain more than one nucleus. In the older parts of the growth, they are usually filled with fat-granules. When an epithelioma has undergone ulceration, the surface is frequently covered with prominent masses like large granulations, and the diagnosis of the nature of the growth can often be made by removing one of them and submitting it to microscopic examination. If in a simple ulcer the skin be completely destroyed, epithelium is never found except at the margins ; in an epitheliomatous ulcer, on the contrary, it is found at every part of the ulcerating surface. The *vessels* of epithelioma are abundant, but not so plentiful as those of scirrhus or encephaloid. As to the relation of the growths to the *lymphatics*, there is some difference of opinion. Thiersch and Waldeyer believe that they have demonstrated a lymphatic endothelium covering the cylinders of cells, and consequently are of opinion that the epithelium is actually within lymph-spaces. The anastomosis between the cancer-cylinders is said exactly to resemble that normally seen between the lymph-spaces. The secondary tumours present the same general characteristics as the primary growth, but they are usually softer, and the epithelial nests are always less abundant and sometimes wanting.

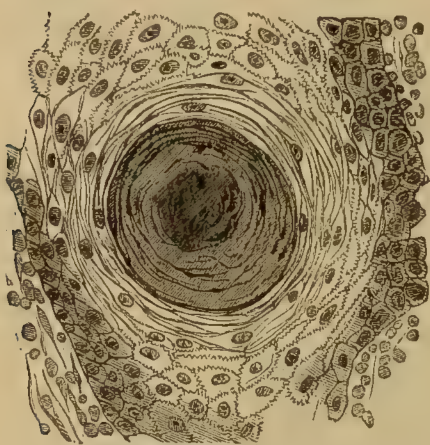


Fig. 405.—Epithelioma of Anus (188 diam.). Illustrates the structure of an epithelial globe, and shows the spinous cells which occur normally in the Malpighian layer of the skin.

The mode of growth of a squamous epithelioma can often be observed without difficulty. If, for instance, a small warty growth from the lip be removed in an early stage and examined microscopically, it will be found to be composed of hypertrophied papillæ covered with an exuberant growth of scaly epithelium. The papillæ increase in size as the centre of the growth is approached. The cutis vera beneath the large papillæ and the papillæ themselves are infiltrated with small round cells. In the circumferential parts of the growth the epithelium will be found to be entirely superficial, but in the central parts, between two or more papillæ, a process of epithelium cells will be seen forcing itself into the cutis vera, which is very abundantly infiltrated at that spot with small round cells. So long as the epithelium is all superficial the growth cannot be said to be malignant, and would be classed as a simple wart ; whenever the epithelium cells can be seen bursting through between the papillæ and extending into the tissues beneath the growth is undoubtedly cancerous.

The scaly tongue undergoing conversion into epithelioma also offers a favourable opportunity of observing the same process.

Diagnosis.—The diagnosis of epithelioma from the other forms of cancer is not always easy. The principal points that should guide the Surgeon are: 1. The almost invariable occurrence of the epithelioma on the mucous or muco-cutaneous surfaces. 2. Its early ulceration; often almost from the very commencement. 3. The rapidity with which ulceration follows on the new growth. 4. The origin of the disease from some evident source of external irritation. 5. The absence of all evidence of contamination of internal organs.

The **Prognosis** of squamous epithelioma is far more favourable than that of scirrhus or encephaloid. Its superficial origin makes it possible for the Surgeon to recognize it early and remove it in some cases before the glands are affected, and even after glandular enlargement has taken place there is hope in some cases of completely eradicating the disease by removing the affected glands.

Recurrence after Removal takes place in squamous epithelioma as in glandular cancer in the scar or its immediate neighbourhood, and in the lymphatic glands, and in these situations is due to the same pathological conditions. Distant recurrence is, as before stated, less common, but when it does not take place it is due, as in other forms, to dissemination of cancer-elements throughout the body. In one case in which I removed an epithelioma of the tongue recurrence took place in one of the toes and in the lung after a lapse of nearly two years.

Epithelioma presents the peculiarity, however, of re-appearing in some rare cases in the neighbourhood of the primary growth and yet not in connection with it. In these cases it would appear as if there was a tendency to epithelioma in a particular region of the body, which becomes more or less widely affected in different parts in a consecutive manner. Thus I have seen after the removal of an epithelioma of the lip on one side, recurrence of the disease inside the mouth on the other side. This mode of recurrence is slower than the first. I have seen from three to four years elapse between the removal of the epithelioma on the left side of the lower lip and its recurrence inside the right cheek.

It would appear as if epithelioma were sometimes capable of transplantations or of inoculation so as thus to be locally multiplied. I have seen an epithelioma of one labium apparently inoculate an abrasion on the opposite one where a fresh centre of disease developed, and an epithelioma of the tongue infect the lower jaw through the contiguous alveolus of a loose tooth.

3. Columnar Epithelioma.—This form of tumour has frequently been called "adenoid cancer," but the term columnar epithelioma is less likely to lead to confusion and more correctly expresses the nature of the growth. It occurs as a rule at the same age under much the same conditions as squamous epithelioma. It is confined to those regions which are naturally covered by columnar epithelium, and forms the most common tumour of the pylorus and intestine, including the rectum. During the ten years 1871 to 1880 there were admitted into the surgical wards of University College Hospital twenty-five cases of cancer of the rectum described as columnar epithelioma, and nine in which the form of cancer is not clearly stated, which were probably of the same variety. Four cases are recorded as having been met with in the

sigmoid flexure and one in the antrum. Of the fifty cases of cancer of the stomach and fifteen of the intestine admitted into the medical wards, it is probable that many, if not most, were columnar epitheliomata, but the report contains no information on this point. It is met with also in the uterus and gall-bladder.

Appearance and Progress.—A columnar epithelioma bears the same relation to the papilloma of the intestine that the squamous epithelioma does to the common wart on the skin. Just as many squamous epitheliomata commence as warty growths, so a columnar epithelioma may begin as a papillary growth from the mucous membrane. A simple papilloma as it increases in size keeps its superficial character, and becomes in most cases pedunculated and shows little tendency to ulcerate. A columnar epithelioma spreads widely with a somewhat firm fleshy base. Its surface remains papillary at the circumference, but soon ulcerates in the central parts, becoming rugged and irregular, and bleeding readily and abundantly. The growth extends through the whole thickness of the gut, and may implicate neighbouring viscera. Such growths come under the observation of the Surgeon chiefly in the rectum, and occasionally he is called upon to perform colotomy for similar tumours of the colon. All the tumours of the pylorus that have been removed have been of this nature. Columnar epithelioma shows a much lower degree of malignancy than squamous epithelioma. It grows as a rule slowly, and

Fig. 406.—Columnar Epithelioma of tranverse Colon (188 diam.). One tube is cut obliquely, the others transversely; the epithelium is irregular in shape and size, and is sometimes arranged in more than one layer. The stroma is fibrous, containing small round cells.

frequently does not affect the lymphatic glands till a late period of the case. Visceral recurrences are rare, and are met with chiefly in the liver.

Death commonly takes place from the local disease, either from exhaustion from the discharge and loss of blood or from obstruction of the bowel or pylorus.

Structure.—A section of such a growth (Fig. 406) shows it to be composed of tubes lined with columnar epithelium, bound together by a delicate connective tissue, more or less infiltrated with small round cells. The tubes resemble gigantic crypts of Lieberkühn. By the microscope alone it is not always easy to distinguish these tumours from simple papillomata covered with columnar epithelium, in which the bases of the papillæ on section give the appearance of tubes. The irregularity of the structure and the greater cell-

infiltration of the connective tissue would lead to a suspicion of malignancy. If the base be examined and the proper structure of the tumour be found implicating the muscular coat or extending to neighbouring parts, its malignant nature is put beyond a doubt.

The secondary growths met with in the glands and liver maintain the characteristic features of the primary tumour, so that a tissue, looking like crypts of Lieberkühn irregularly massed together, may be found in the lymphatic glands or in the liver. In the lymphatic glands of the groin these tumours may break down and ulcerate, as in squamous epithelioma.

Diagnosis.—The diagnosis of the nature of the growth can be made only when it is situated in the rectum. It is then often possible to remove a small portion for microscopic examination.

Prognosis is always very grave on account of the situation in which the tumour forms. Limited growths may be safely removed from the rectum, and lately such tumours have been excised both from the colon and pylorus, the parts being united by suture of the intestine, but these operations have so far not been attended by any great measure of success.

Other Forms of Cancer were formerly described, the chief of which were Osteoid Cancer and Melanotic Cancer. Osteoid Cancer was the name given to the tumour now known as Osteoid or Ossifying Sarcoma (see p. 1002). The growths formerly described as Melanotic Cancer are also now classed with the sarcomata. It is possible that there may be a pigmented form of epithelioma, but if such a tumour does exist it must be of great rarity.

Treatment of Cancer.—The treatment of cancer will necessarily be in a great measure dependent on the view that is taken of its origin. The constitutionalists would naturally endeavour to discover some method of preventing the development of or of eradicating that blood-poison, or that general tendency which they suppose to underlie the local affection. They would necessarily discard operation as being not only useless, but erroneous in principle—as erroneous as it would be to amputate the foot to cure the gout. The localists, on the other hand, necessarily rely on the removal of the primary local disease at as early a period as possible, as the only means of preventing secondary deposits, and constitutional infection. Hence the discussion as to the origin of cancer has a most important practical bearing on the treatment of the disease. All **Curative Constitutional Treatment** is certainly useless, no constitutional remedies appearing to exercise any material influence on the disease. I am not acquainted with any case of cancer, either from my own observations, from conversation with other Surgeons, or from published statements, that affords satisfactory evidence of cure by an internal remedy. It is true that many so-called cases of cancer have, at various times, been stated to have been cured by different medicines ; but it must be borne in mind that, in a less advanced state of pathological knowledge than exists at the present day, almost all hard chronic tumours were called "scirrhous," and many intractable ulcers "cancers" ; mistakes which are not unfrequently committed, and sometimes unavoidably so, even with the improved means of diagnosis that we at present possess. Not one of the many remedies that have been vaunted as being specific in this disease, and by which cures have been stated to have been effected, has obtained the confidence of the profession, or has, on further trial, corresponded in its effects to the statements of those who introduced it. I therefore think it but waste of time to discuss the

supposed benefit to be derived from hemlock, sanguinaria, condurango, Chian turpentine, iron, arsenic, iodine, cod-liver oil, or lemon-juice, in the treatment of cancer. But though curative treatment can effect nothing in these cases, much may be done by proper *Palliative Treatment* towards retarding the progress of the cases that do not admit of operation. With this view, the diet should be mild, nutritious, easy of digestion, unstimulating, and sufficient to support the strength under the wearing influence of pain and discharge; and the preparations of opium, of conium, and of hyoscyamus, must be freely administered in order to relieve the patient's sufferings, and to procure rest.

The **Local Means** are those upon which the Surgeon justly places the chief reliance in these affections. The **Palliative Local Treatment** consists in the use of means calculated to retard the growth of the tumour, to lessen the pain attending it, and to remove the fœtor that arises if it be ulcerated. In order to prevent the rapid extension of the tumour, it is of great importance to subdue all local excitement within and around it; the disease will usually extend with rapidity, proportioned to the amount of action existing in the part, any inflammatory condition of the neighbouring tissues being especially prejudicial in this respect. Hence, in these circumstances, the occasional application of a few leeches will often be of considerable service. No counter-irritation, however, ought to be employed in the vicinity of the cancerous part, as it hastens the process of ulceration; the skin being apt to become rapidly infiltrated by the cancerous disease under it, if irritated by the application of iodine and other stimulants. If the tumour be painful, and the skin covering it still unbroken, great relief may be obtained by the application of belladonna-plasters. In some cases I have found powdered conium, spread on cotton-wadding, useful in the same way. As it is of importance to prevent, as long as possible, any breach of surface, the application of these sedative plasters and powders should be persevered in with the view of supporting the integument. The local application of ice, so as to freeze the tumour more or less completely, has been recommended by J. Arnott; it may, possibly, in some cases retard the growth or lessen the pain, but there is no evidence to show that it can be considered as a curative agent. When the tumour is ulcerated, the fœtor must be diminished by the application of weak solutions of chloride of zinc, of chloralum, or of permanganate of potash, to which opiates may be advantageously added with a view of lessening the pain. Iodoform sprinkled over the ulcerating surface will often be found to diminish both the fœtor and pain. If the smell of the iodoform is unpleasant to the patient, an ointment may be used composed of iodoform ʒj, eucalyptus oil ʒj, paraffin and vaselin *a.a.* ℥iiss. This may be applied on a piece of muslin and the parts covered with a sheet of salicylic wool.

The **Curative Local Treatment** of cancer embraces three methods, viz.: destruction by caustics; absorption by pressure; and removal by the knife. All these local means are employed on one principle, viz., on the supposition that the cancerous tumour which it is proposed to destroy, to absorb, or to extirpate, is primarily a *local* disease; that, if this local malady can be removed sufficiently early, constitutional infection may be prevented; and that, even if this have to some extent taken place, fatal contamination of the system may be retarded by the removal of the local source of that constitutional infection.

The great objection that has been urged against operating in this disease is, that cancer being assumed to be from the first a constitutional affection, it is useless to remove the local tumour, leaving the constitutional vice unrelieved. If this objection were tenable, it would apply to the removal of cancers in any way, and would have as much force against removing cancerous growth by caustic, by pressure, or by congelation, as against extirpating them by the simpler and speedier means of the knife, and in fact must lead to the conclusion that none but local palliatives are proper in this disease. For such an argument as this to have any value, it must first be shown that cancer is always *ab origine* a disease depending on the actual presence in the blood of a certain morbid material, and that it is not in any cases primarily local, in so far that any tendency to the formation of cancer has strictly limited its action to the part where we find the cancer developed. The arguments which have already been adduced, however, and the results of experience, appear to me to be conclusive as to cancer being, for all surgical purposes, primarily a local disease, becoming constitutional secondarily by contamination of the blood and absorption into the system, and consequently to justify operation for the removal of cancerous tumours in suitable cases.

Caustics.—The employment of caustics for the destruction of cancers has, in all ages and countries, been resorted to by empirics, who profess to remove tumours of a malignant nature, by secret remedies, less painful and more effectual than the knife. As their application, to use Velpeau's expression, requires neither acquaintance with anatomy nor operative surgery, these remedies have always been popular with many who have neither the knowledge nor the skill to use the knife. In this country, however, they have never enjoyed any very extended reputation; and in fact they have, perhaps, not been legitimately employed to the extent that they deserve, especially in ulcerated and recurrent cancers, or in those so situated on the skin and muco-cutaneous surfaces as not to admit of being very readily or safely extirpated by operation.

The great objection to the use of caustics has been the severity and the continuance of the pain induced by them, which lasts not only for hours, but for days—more intense and prolonged than any occasioned by the knife; and as it is usually necessary, in order to destroy effectually the morbid growth, to repeat the application of the caustic several times, the suffering is often greater than the most resolute patient can submit to.

The chief argument in favour of the use of caustics is the statement, that cancers thus destroyed are less liable to recur than when extirpated by the knife. There is, however, no evidence before us in proof of the truth of this doctrine. It is impossible to believe that the mere method of removal of the local disease can influence the progress of the case. If secondary infection have taken place, it can signify very little whether the local disease be extirpated by the knife or by caustics. If no infection exists, it appears to me that the patient must be equally safe in whatever way the local disease is removed, provided it be thoroughly and effectually extirpated. Another advantage urged in favour of caustics, in the correctness of which Velpeau acquiesces, is, that enlarged lymphatic glands are more likely to go down under their use than when the primary cancer is extirpated by the knife. Subsequent experience has not however confirmed this statement. Some of the advocates of the use of caustics in the treatment of cancer pretend that the particular agent employed exercises on the morbid structure a specific

action, which is confined to it, and does not extend to the neighbouring healthy tissues. But this assertion is entirely destitute of foundation.

Caustics are more frequently applicable to epithelioma than to scirrhus or encephaloid. In certain cases the disease is so situated, as in some parts of the face or in the deeper cavities of the body, that it cannot be dissected out, and in these its removal may be effected by caustics ; but, if these agents be employed, care should be taken that they be freely applied and be sufficiently strong, so as thoroughly to destroy the whole of the morbid textures. Inefficient caustics, such as nitrate of silver, irritate and do not destroy the tissues to which they are applied, and in this way do much mischief. Inflammation is excited around the growth, and the inflamed tissues become rapidly infiltrated by the abnormal structure, which thus extends with much greater rapidity than would otherwise have been the case.

The caustics that have been and that are employed in the treatment of cancers are very various. They cannot be used indiscriminately, and consequently we must briefly consider them separately.

1. The *concentrated mineral acids*, especially the fuming nitric and anhydrous sulphuric acids, are often advantageously employed. The concentrated nitric acid may be usefully applied to small superficial cancerous ulcers ; it rapidly destroys the tissues, and does not spread too widely, but it is not potent enough for the destruction of tumours. The glacial sulphuric acid, made into a white paste with asbestos, as used by Michel, or rubbed into a black paste with powdered saffron, is the caustic which Velpeau extols as the most efficient in cancerous tumours, more particularly those of a fungating or bleeding kind. It converts the part to which it is applied into a thick, hard, carbonized eschar, with but little surrounding inflammation ; and, as its action is rapid, the pain is not prolonged. On the separation of the hard slough, a healthy granulating cavity will be left, which cicatrizes rapidly with contraction. It acts also as a hæmostatic, rapidly shrivelling and drying up large bleeding and discharging growths.

2. The *caustic alkalies*, especially potash and lime, either alone or in combination, in the shape of the Vienna paste, or fused into sticks, are very energetic in their action; but they have the disadvantage of spreading widely if applied to a large surface, and, by softening or dissolving the parts, giving rise to a tendency to hæmorrhage. They may, however, be advantageously applied to small epithelial cancers of the face.

3. Various *mineral salts*, more particularly the chlorides of antimony and zinc, the acid nitrate of mercury, and arsenious acid, are often employed with much success in the treatment of cancerous ulcers and growths.

Of the various *chlorides*, that of *zinc* is the most useful. This is applied by being made into a paste containing one part of the chloride to four parts of flour, moistened with a little water, to which one-twentieth part of extract of opium may be added to diminish pain. It must, in order to act, be applied to a raw surface : hence it is customary first to destroy the skin with nitric acid, and then to apply the chloride. Canquoin states that a paste, made of equal parts of the chloride and of flour, four lines in thickness, and applied for forty-eight hours, destroys the parts to the depth of an inch and a half. When of less strength and substance, its action is proportionately limited. There are two methods by which a tumour may be attacked and destroyed by caustic paste : either from the circumference, or from the centre. When the tumour

is large and rapidly growing, it may be most advantageously destroyed from the circumference, at its junction with the healthy tissues. This may be done by the plan adopted by Maisonneuve—of making the paste into small sticks, or pencils, which are pushed deeply and at short intervals into the substance of the tumour around its circumference, so that its tissue becomes penetrated by the action of the caustic in all directions, and its vitality thus rapidly destroyed. In small tumours, and those that grow with less rapidity, in which there is no great risk of the rapidity of their growth overtaking and passing beyond the destructive effects of the caustic, the paste may be applied to and around the centre, and the disease in this manner extirpated. In other cases, the tumour may be deeply and rapidly attacked by applying a layer of the chloride of zinc paste over the whole of its surface. The slough produced by this application is then incised, or scored longitudinally at equal distances of about half an inch, until the parts beneath, to which the caustic has not penetrated, are reached by the incisions so made : pieces of lint covered with the deliquesced chloride are put into them, and afterwards fresh incisions are made until the cauterizing influence has extended to the bottom of the tumour, which finally sloughs out in a mass. Of the utility of the chloride of zinc as a caustic, there can be no doubt ; but the chief objection to its use lies in the intensity and continuance of the pain occasioned by it. This, however, may be lessened by an admixture of extract of opium, or, as L. Parker has suggested, by freezing the part before the caustic is applied, and continuing the application of the frigorific mixture during the time of the action of the caustic. Landolfi has recommended the use of the chloride of bromine in combination with those of gold and zinc ; but this caustic does not appear to possess any decided advantage over the simple chloride of zinc, and is objectionable on account of the fumes evolved during its use.

Arsenic exercises a powerful action upon cancerous growths, and is the chief ingredient in many of the secret preparations used by empirics ; it is, however, a dangerous agent, and excites great inflammation and pain. If too freely used, it may induce poisoning, and not a few deaths have resulted in this way ; it should, accordingly, not be applied at any one time to a surface exceeding a shilling in size. The most convenient mode of applying it appears to be Manec's paste, composed of one part of arsenious acid to eight of cinnabar and four of burnt sponge, rubbed down to a proper consistence with a little water.

Sulphate of zinc, dried, finely levigated, and made into a paste with glycerine, or an ointment with lead, has been very strongly recommended by Simpson, as one of the most efficient and convenient of all caustics in rodent and cancerous ulcers. In action it somewhat resembles the chloride of zinc, but is less painful.

Of all these caustics, I should certainly say that the deliquesced chloride of zinc is the safest and most efficacious, more particularly when a scirrhous tumour has to be destroyed. When an encephaloid fungus has to be attacked, the concentrated sulphuric acid is preferable, owing to its coagulating and hæmostatic properties. When small cancerous sores have to be destroyed, the nitric acid, the arsenical paste, or the chloride of zinc, made into a paste with flour and extract of opium, may very conveniently be used.

Compression is a plan that has been alternately greatly extolled and much depreciated. It was fully tried at the Middlesex Hospital, by Young, more

than fifty years ago, and unfavourably reported upon by Sir Charles Bell at that time ; it consequently fell into disuse in this country, but was revived by Recamier in France, and employed largely by him. Although he published a favourable account of this practice, it made but little progress amongst French surgeons ; the only one who seems to have used it to any extent being Tanchou, who employed a peculiar topical medication conjoined with it. In this country the practice fell into complete oblivion, until J. Arnott some years ago invented a mode of employing pressure by means of an elastic air-cushion ; since which time it has been often employed, but with no real success as a means of cure.

In employing pressure, Young had recourse principally to plasters and bandages. Recamier used amadou applied with an elastic roller ; and Tanchou recommended spring-pads, under which small bags or pieces of cotton-wadding impregnated with various medicinal substances were placed, so as to protect the skin and act upon the tumour. Arnott's plan consisted of pressure exercised by a caoutchouc air-bag, held in its place by straps, and pressed upon by a truss-spring, the pressure exercised by which was made to vary from two-and-a-half to twelve or even sixteen pounds. I have employed all these different plans, but have never found permanent advantage from any of them.

The first question that necessarily arises in reference to the employment of pressure in these cases is, whether it can effect a cure. This it could be expected to do only by producing atrophy, and subsequent absorption, in the strictly local forms of cancer. The only case on record, with any pretension to a conclusive character in this respect, is one, related by Walshe in his excellent *Treatise on Cancer*, of a cure of a tumour of the breast believed to be cancerous, by compression. But even this instance I cannot look upon as by any means conclusive ; for, although no one can entertain a higher opinion than I do of the very remarkable diagnostic skill possessed by Walshe, yet I think there can be no doubt in the mind of any Surgeon that it is absolutely impossible to determine in many cases, by any amount of knowledge or skill, the true nature of a chronic tumour of the breast ; and, in fact, the most experienced practitioners frequently find, after the removal of the tumour, that it was of a different character from what they had previously anticipated. This difficulty attaches to Walshe's case ; and I think that there is no proof that the tumour of the breast, which underwent absorption under the pressure of Arnott's apparatus, was of a truly cancerous nature, and that it was not a chronic inflammatory induration, which, as every one knows, will disappear under this kind of treatment.

But, if compression cannot be shown ever to have cured a cancer, can it not retard the progress of this disease, or relieve the sufferings attendant upon it ? I believe that in some cases it may certainly do both, though in others it is as unquestionably injurious. It appears occasionally to retard the growth of the tumour when applied in the early stage, simply by preventing its expansion, and perhaps by compressing its nutrient vessels, and so diminishing the supply of blood sent to it, and by causing absorption of surrounding inflammatory infiltration ; in these cases likewise it relieves for a time the pain by lessening the turgescence of the part. In other cases, however, I have known it to act injuriously by pressing out and diffusing the tumour more widely, appearing to increase the tendency to implication of neighbouring parts, and occasioning great suffering. When the tumour is ulcerated, or if the skin covering it be

inflamed, pressure cannot be employed with any advantage; and, most commonly, irritable sensitive patients cannot support the constriction of the chest that it necessitates.

Excision.—With regard to the question of removing cancers by the knife, much difference of opinion exists among Surgeons; for, though all deprecate indiscriminate recourse to this means, some go so far as to dispute the propriety of ever operating for this disease, whilst others would restrict the operation to certain cases of a very favourable character. These divergences are necessarily of considerable importance, and require attentive examination.

The objections that have been urged against the general propriety of operating in cases of cancer, do not apply so much to the operation itself, the risk attending which is not greater than that of other operations of similar magnitude, but are rather based on the supposition that cancer is originally a constitutional affection, and that the patient is consequently liable to speedily suffer from a return of the disease, so that an operation that is at least unnecessary will have been performed. This objection, however, as has already been remarked, equally applies to all other means of local removal, as by caustics or compression, as well as to extirpation by the knife; and, if carried to its logical conclusion, must necessarily preclude any attempt at removal, by any means, of the local disease. That this objection, so far as the liability to return of the cancerous disease after operation is concerned, is to some degree a valid one cannot be gainsaid; the experience of all Surgeons tending to establish the fact, that the majority of patients operated upon for cancer die eventually, and usually within a limited time, from a recurrence of the disease. Thus, A. Cooper states, that in only nine or ten cases out of a hundred did the disease not return in three years; and Brodie found that it proved fatal generally in two or three years after the operation.

In cancer of the breast, however, better results have of late been obtained by free removal of the affected gland with the surrounding skin and the axillary glands. Thus, out of forty-six cases operated on by Mitchell Banks, ten patients were alive and free from recurrence at different periods, varying from two to ten years, after the operation, and in five more no recurrence had taken place from one to two years after the operation. Küster states that in 26 per cent. of his cases no recurrence had taken place three years after the removal of the breast.

In determining the advisability of operating in cases of cancer, several questions of great importance present themselves to the consideration of the Surgeon. He has first to consider whether the operation is likely to rid his patient completely of the disease; or, in the event of its not doing so, whether life may not be prolonged by the removal of the cancerous tumour; or, lastly, whether his sufferings may not be much lessened by the removal of the local affection, although there be no prospect of really prolonging life.

The principle on which all operations for the removal of cancer are undertaken is this: either that, the disease being local *ab origine*, the secondary manifestations can be prevented by a timely removal of the primary growth; or that, even if the tumour be the result of a constitutional predisposition or vice roused into activity by local causes, the excision of this morbid growth removes from the system a new centre and source of constitutional infection; so that, if the operation be unsuccessful in completely eradicating the disease,

it may yet be productive of much good in preventing the contamination of the system. The two following questions will therefore present themselves to the Surgeon in considering this subject.

1. Can cancer be cured, or, rather, completely extirpated from the system by excision?

That in some cases a cancerous tumour may be removed with every expectation of the patient being completely freed from the disease, cannot, I think, be doubted; although it may be true that such instances are rare. Yet they do occasionally fall under the observation of Surgeons, and certainly seem to prove that the affection is not primarily constitutional, and that, if happily we can succeed in removing it during its local condition, the patient will be rescued from a return of the affection. Velpeau states that he has perfectly cured patients by the removal of cancerous tumours—at least, that no return has taken place for 12, 15, or 20 years after extirpation. The evidence of Brodie on this point is extremely valuable; writing in 1846, that eminent Surgeon states, that "So long ago as 1832, I removed a breast affected with a scirrhous tumour, and the lady is still in good health—at least, she was so last year. Since the operation she has married, and had children. Last year I was called to see a lady on account of another complaint, on whom I performed the operation thirteen years ago, and found that she continued free from the old disease; and, very lately, I have heard of another lady whose scirrhous breast I removed six years ago, and who continues well." The opinion of Fergusson is also very positive on this point, and he speaks in a tone with which I perfectly agree. He says: "Nevertheless, as excision gives the only chance of security—a point on which most parties seem to agree—an operation should always be resorted to, provided the knife can be carried beyond the supposed limits of the disease; and, moreover, I deem it one of the duties of the practitioner to urge the patient to submit to such a proceeding." The results obtained by Banks and Küster still further illustrate the possibility of occasionally eradicating the disease by operation. The opinion of these eminent Surgeons, supported as it is by the general practice of the profession, tends to show that in some cases, at least, the disease may be extirpated from the system by excising the tumour before the constitution has become implicated.

2. If cancer cannot be actually cured by excision, may not life be prolonged and health improved by an operation?

I am decidedly of opinion that this is possible; and that, though a patient may at last be carried off by some of the recurrent forms of cancerous disease, health may be improved, life may be prolonged, and much suffering may be spared, by a timely operation. It may often be observed that, after the cancer has been removed, the digestion becomes stronger and the patient gains flesh; the colour of the complexion returns, and the spirits greatly improve; the system being relieved from a source of local irritation, and the mind from a cause of disquietude that has undermined the general health of the patient. This is more particularly the case in encephaloid cancer, in which early removal of the disease is unquestionably successful, in many cases, in prolonging life. The observations of Paget on this point are peculiarly valuable. He states the average duration of life of those patients labouring under this form of disease, in whom the primary affection is removed, to be about twenty-eight months; whilst the average life of

those in whom the disease is allowed to run its course, is not more than two years.

I think that the introduction of anæsthetic agents into operative surgery has very materially affected the bearings of this important question. So long as an operation was a source of great pain, and of much consequent anxiety and dread, a Surgeon might very properly hesitate to subject his patient to severe suffering with so doubtful a result; but now that a patient can be freed by a painless procedure from a source of great and constant annoyance, discomfort, and suffering, the Surgeon may feel himself justified in thus affording him a few months or years of comparative ease, though he may be fully aware that, at the expiration of that time, the affection may return, and will then certainly prove fatal. Even under these circumstances, the patient's condition may be much improved; for the recurrent is frequently less distressing than the primary disease; since, as it often takes place in internal organs, it is not attended with the same amount of local pain and distress.

The introduction of anæsthetics and the improved methods of treating wounds have moreover enabled the Surgeon not only to remove the primary growth more freely and thoroughly, but to follow it up to the nearest lymphatic glands, without fear of the consequences of so extensive an operation. So much is this the case that many Surgeons make it a rule, especially in cancer of the breast, not to wait for evident infection of the glands, but always to remove them at the same time as the primary tumour, and this mode of operating has so far been attended with the most satisfactory results.

In discussing the propriety of operating in a case of cancer the Surgeon can, however, have little to do with general or abstract considerations. He has to determine what had best be done in the particular case; and it will serve him little, in coming to a conclusion as to the line of practice that he should adopt, to refer to the statistics of the gross results of operations, or to general comparisons between the results of cases that are not operated upon and those that are. The whole question narrows itself to the point, as to what should best be done in order to prolong the life or relieve the suffering of the particular individual whose case is being considered. In order to come to some definite conclusion on this, it is necessary to classify the different cases of cancer, and to arrange them under the heads of those in which no operation is justifiable; those in which the result of any such procedure would be very doubtful; and those in which an operation is attended with a fair prospect of success.

Most of the following rules apply equally to true cancers and the malignant sarcomata formerly classed as such.

In no case should any operation be undertaken till the liver has been examined by percussion and palpation and found free from disease. If there are no symptoms such as cough, pleuritic pain, or hæmoptysis, it is probable that a secondary tumour in the lungs, even if present, would be too small to be recognized by any method of physical examination. Still it is always safer to examine the chest also. I have seen a case in which a Surgeon removed the upper jaw for a tumour which turned out to be a secondary scirrhus, when by palpation of the abdomen the primary tumour of the pancreas and secondary nodules in the liver could easily have been felt. I know also of another case in which the eyeball was removed for a melanotic sarcoma, when the liver was studded with secondary growths which could readily have been felt through the

abdominal walls. In such cases operation is clearly improper. The urine should also in every case be examined for albumen and sugar.

1. **Cases not proper for Operation.**—(*a*) It is a rule in surgery which should never be deviated from, that no operation should ever be undertaken for the removal of a malignant growth, unless the whole of the tumour and the tissues infiltrated by it can be completely removed. It is necessary to remove not only the tumour but the surrounding tissues to some extent, even though apparently healthy. (*b*) The operation ought never to be performed in cases in which several malignant tumours exist in different parts of the body at the same time. Here the disease has evidently affected the constitution, and cannot be removed by any series of operations. (*c*) If the cachexia be strongly marked, it is useless to remove the local affection, as probably some secondary visceral tumour is already forming. (*d*) If the tumour be of very rapid growth and soft, and its margin very ill-defined, it has probably infected the surrounding tissues so widely that it will speedily reappear in the cicatrix if removed. (*e*) If the whole of the affected organ cannot be removed, as a bone, or if the skin or mucous membrane be so widely affected that it cannot be removed, or if lymphatic glands are enlarged which cannot be dissected out, it is useless to attempt the excision of the primary growth, as a speedy relapse will certainly ensue. (*f*) In the very chronic and indurated cancers of old people, it is often well not to interfere, as in these cases the affection makes such slow progress, that it does not in any way shorten life, whilst the operation might be attended with serious risk at an advanced age.

2. *Doubtful Cases.*—Those cases in which the result of an operation is extremely doubtful, but in which no other means offer the slightest prospect of relief, have next to be considered. (*a*) Malignant sarcomata of the eye, and cancers of the tongue and testes, belong to this category; for, though more liable to return than similar affections of any other part of the body, yet they may be considered fit cases for operation, inasmuch as in no other way has the patient the slightest chance of being relieved from his disease. (*b*) In cancers that are already ulcerated, the Surgeon may sometimes operate in order to give the patient ease from present suffering, or, perhaps, as in some cases recorded by Brodie, with a view of prolonging life; but he can have little expectation of effecting a permanent cure. (*c*) If the tumour be so large, or be so situated, that its removal cannot be undertaken without so serious an operation as to occasion in itself considerable risk to life, the propriety of operating is always very doubtful.

3. *Cases proper for Operation.*—Those cases in which an operation is, in my opinion, not only perfectly justifiable, but should be urged upon the patient as affording the best prospect of preserving or prolonging life, are those in which the disease has originated in a person otherwise in good health, and in whom there is so far no cachexy. In scirrhous cancer, if the disease be slow in its progress, single, distinctly circumscribed, without adhesions to or implication of the skin or glands, and more especially if it be attended with much pain, or with immediate risk to life from any cause, and if the whole of the growth, together with a sufficient quantity of the neighbouring healthy tissues in which it is imbedded, can be removed with ease, the case may be looked upon as a fit one for operation. If the glands are affected to a limited degree, and only to such an extent that they can be removed without danger, the operation

should still be urged on the patient, provided the general health is unimpaired. In encephaloid cancer, or soft malignant sarcomata, the rapidity of the growth need not deter the Surgeon from operating provided the whole primary tumour and the large lymphatic glands, if present, can be removed; early operation should be practised, with the view of prolonging life, if nothing more. In epithelioma the removal of the primary tumour with the glands in an early stage of infection is a more hopeful proceeding than in either of the forms of glandular cancer.

An important question in connection with operations for cancer is, at what period of the growth they may be done with the best prospect of success. In former times Hervez de Chégoin and Leroy d'Etoilles and others have advocated delay, asserting that the results obtained were better when the operation was performed after the tumour had lasted. Such a statement as this can have been the result only of imperfect observation. Other things being equal, the earlier the tumour is removed the better the chance of prolonged or permanent relief. There is no fact in Surgery more certain than this. In the preceding pages it has been pointed out how strong is the evidence that all cancers are primarily local, and that the glands and afterwards the viscera become infected by actual particles of the tumour transplanted to them from the original growth. Accepting this as true, it necessarily follows, as was pointed out by De Morgan, that the disease may be local and capable of complete removal up to a certain minute, and the next it may have extended beyond the reach of operative interference. We cannot possibly tell when this eventful change takes place. All we can do is to try to anticipate it by operating at the earliest possible time. Not a day should be lost after the disease is recognized. In doubtful cases it is far better not to wait till unequivocal signs of the malignant nature of the growth appear, but to cut into it, and if necessary to remove a slice for examination at the earliest possible time, proceeding immediately to complete removal if it be found to be malignant. Errors will arise, do what we will to prevent them, and it is far better to err by making an unnecessary incision, or even removing a mass of chronically inflamed tissue or a syphilitic gumma, than to leave a cancerous growth till its complete extirpation becomes impossible.

EXCISION OF TUMOURS.

In describing the different forms of encysted tumour, the operative procedures necessary for their removal have been adverted to. We may now conveniently consider the steps that are generally necessary for the extirpation of solid tumours from the soft parts.

Tumours may be removed by the knife, by the écraseur, by the cautery, or by ligature.

Removal of Tumours by the Knife.—In the removal of tumours, the first point to be attended to is the arrangement, shape, and direction of the necessary *incisions*. These should not only have reference to the size of the growth, extending well beyond it at each end, but must also be planned with due regard to subjacent parts of importance. As a general rule, they should be carried in the direction of the axis of the limb or part, and parallel to the course of its principal vessels; they must extend not only over the whole length of the tumour, but also a little beyond it at each end: no cross-cuts

should be made, if they can be avoided, and this may usually be done by attention to the proper position and extension of the linear incisions. In removing a simple tumour, no skin should, as a rule, be taken away, a simple cut being made ; but if the integumental tissues be either very abundant and loose, or else adherent, an elliptical portion of them may be excised together with the tumour. In other instances, again, a semilunar flap of integument may with advantage be turned up from the tumour, the surface of which is then fairly exposed ; this, however, can be done only in some simple tumours, such as fatty growths. In excising malignant tumours the skin must in most cases be freely cut away. It is better to leave a healthy surface to heal by granulation, than leave any part of the skin behind which may be infected by the growth. The flaps covering the growth should be freely but cautiously dissected back, so as to expose its sides and base ; as these are approached, and the Surgeon reaches the neighbourhood of its more important and deeper connections, increased care will be necessary, as it not unfrequently happens that the tumour is in closer relations with deep-seated blood-vessels and nerves of a large size than would at first appear.

When practicable, the *deep dissection* will best be commenced and carried out from that part of the base of the tumour into which the principal blood-vessels appear to enter ; they are thus early cut, and being once ligatured, or seized in catch forceps, give no further trouble, which they would do were they divided from the direction of their branches towards the trunk, when at each successive stroke of the knife a fresh portion of the vessel would be touched. In carrying on this deep dissection, the operator should proceed methodically from one side of the tumour to the other, the assistants holding aside the skin so as to give as much room as possible, whilst the Surgeon himself, seizing the mass with his left hand, or with a large double hook or vulsellum, and dragging it well forwards, uses the knife by successive strokes, but in a leisurely and careful manner, avoiding all undue haste, until he completely detaches it from its connections. The safety of contiguous important structures will be best secured by keeping the edge of the knife constantly directed towards the tumour, if this be non-malignant; by attention to this rule, tumours may be removed with remarkable safety and ease from the neighbourhood of most important parts. If, however, the growth be malignant, the incisions must be made wide of the disease into the healthy structures around ; unless this be done, portions of the tumour may be left from which fresh growths will rapidly sprout, or tissues apparently healthy may be left which are in reality impregnated with cancer-cells.

After the tumour has been removed, it must be *carefully examined*, with the view of ascertaining whether it be entire ; and, if any portions have been left, these must be properly dissected out. In some situations, as the axilla, the side of the neck, or the groin, where the relations are of great importance, the less the edge of the knife is used the better, and the growth should be enucleated by the Surgeon's fingers or by the handle of the scalpel.

In removing tumours from the neck or axilla the danger of the entrance of air into a half-divided vein, held open by the traction on the tumour, must never be forgotten. (*See* p. 467.)

The Surgeon should rarely undertake the removal of tumours that cannot be wholly and entirely extirpated, as the part left will always grow with greatly increased rapidity, often assuming a fungus character ; this is especially the

case with malignant tumours, the rapidity of increase of which is greatly augmented by partial operations. The exception to this rule consists in the case in which a large ulcerating and necrosing mass may be removed with the view of giving the patient temporary ease, and save him from the annoyance of the putrescence of a disintegrating tumour.

Should, however, the Surgeon have begun the operation with the intention of removing the whole, and have been deceived as to the depth and connections of the mass; if, for instance, he find, after commencing his operation, that the tumour extends more deeply than had been anticipated, and comes into close relation with important vessels, as at the summit of the axilla or in the perinæum, thus preventing him from dissecting it out without imminent risk of destroying the patient, the only alternative left is one that I have seen Liston adopt, and have had occasion myself to practise; viz., to throw a strong ligature, above the apex of the growth as high up as practicable, and then to cut off everything below this. On the separation of the ligature, any portion of the tumour that has been included will be brought away as if it had been removed by the knife.

In some cases it will be found, after dividing the fascia covering the tumour, that the attachments of the growth are not so firm or deep as had been previously expected; this is especially the case in some large tumours springing from the side of the neck and the parotid region, or in the groin. The growth may then often be removed in a great measure by separating the areolar tissue with the handle of the knife, merely dividing those portions of the deeper attachments that are peculiarly dense.

If very free bleeding takes place during the operation two courses are open to the Surgeon, he may either finish the operation with the greatest possible rapidity, even perhaps cutting through outlying lobules of the growth and leaving them to be taken out afterwards, or he may arrest the bleeding as he goes on by Spencer Wells' forceps (p. 408) or ligature. The former plan is best if the bleeding is from multitudes of small vessels, the latter, if it proceeds from a few large trunks. In difficult dissections the parts should, when possible, be rendered bloodless. Where this is impossible the oozing may be best arrested by the application of hot water (p. 401).

The wound that is left after the removal of a tumour usually unites readily by first intention if properly drained and dressed by one of the antiseptic methods described in the chapter on the treatment of wounds. If imperfectly drained, and if the cavity be allowed to become filled with decomposing discharges, severe fever and prolonged suppuration will almost certainly result.

Removal of Tumours by the Écraseur. The écraseur was invented by Chassaignac. It consists of a loop of fine steel chain or twisted wire (thick piano wire is the best), which, having been passed over the tumour or through the tissues to be removed, is gradually tightened by a mechanism in the stem to which it is attached. In applying this instrument it is often necessary, first of all, to insulate and raise the tumour to be removed by passing a thread through or under it (Fig. 408); and then, having applied the loop of the chain round its base, to tighten this and effect the strangulation by working the handle every ten or fifteen seconds, until the mass is detached.

By means of the *Écraseur* (Fig. 407), cancerous and other growths of considerable size are removed with little or no hæmorrhage, in the course of a few minutes, by a process of rapid strangulation and crushing. The

resulting wound is small and puckered in, and often heals with but little trouble. If the mass to be removed be large, two or more écraseurs may be used at the same time, the chains having been passed through the tissues by means of a needle. The action of the écraseur differs according to the kind of instrument used. Chassaignac's original écraseur, armed with a steel chain, and having a to-and-fro movement, acts like a saw. That which is now often employed (*vide* vol. ii., Diseases of the Tongue) acts as a simple constrictor; and its use is therefore less likely to be followed by hæmorrhage.

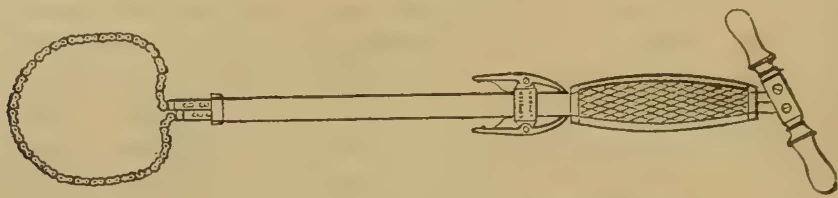


Fig. 407.—Chassaignac's original Steel Chain Écraseur.

This instrument appears to be applicable chiefly to cases in which, as in epithelioma of the tongue, excision is hazardous on account of the hæmorrhage attending it, while the ligature is objectionable on account of the fœtor and discharge resulting from the slow separation of the constricted mass, which sloughs and becomes putrescent. The French Surgeons, however, extend the use of the écraseur to many cases in which in this country the knife is preferred. They suppose that pyæmia is less likely to follow removal by this instrument than by the more ordinary means, purulent absorption less readily occurring while the vessels on the cut surface are crushed together. Experience has not, however, shown this to be the case.

A modification of the écraseur in which the wire was heated by electricity

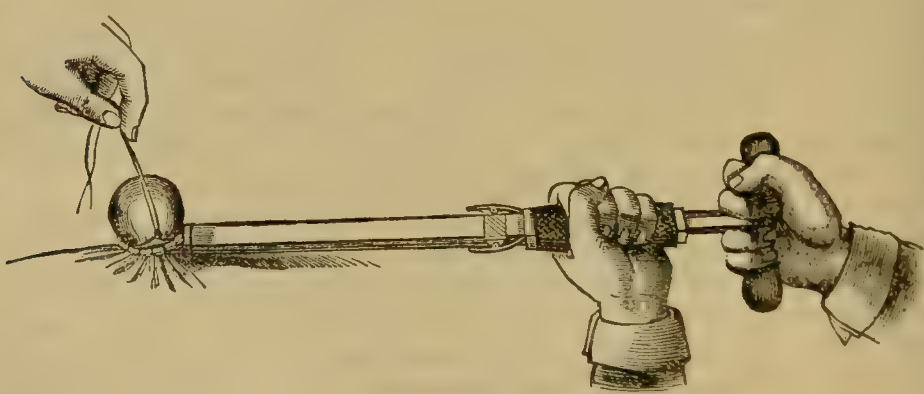


Fig. 408.—Écraseur applied.

at the same time that the noose was gradually drawn in was much in use a few years ago. The galvanic écraseur has, however, fallen somewhat into disrepute. The increased rapidity with which it cut the tissue, and the perfect absence of hæmorrhage during the operation, seemed at first great points in its favour; but experience showed that the wound left was more likely to slough, and secondary hæmorrhage much more frequently occurred than after the use of the simple écraseur.

The écraseur is undoubtedly a useful and valuable instrument, but it should never be employed when the knife can be safely used.

Paquelin's Cautery has in many cases superseded the écraseur in the removal of tumours. The red-hot knife of this instrument divides the tissues cleanly, and efficiently arrests hæmorrhage. The heat at which it can be used may be easily regulated, and if not raised above a dull red heat secondary hæmorrhage rarely follows its employment. In removing superficial growths, such as an epithelioma of the vulva, it can be used at a higher temperature. It then arrests the parenchymatous oozing, but leaves the large vessels spouting, so that they can easily be secured by ligature. When used at this temperature it cuts more quickly and cleanly, and chars the tissues more superficially, and leaves a surface on which a scarcely appreciable layer of slough is formed.

The **Ligature** is now never used except for pedunculated growths or for nævi. It was formerly applied to small epitheliomata of the tongue, but the presence of the foul sloughing tumour in the mouth was not only unpleasant but a positive source of danger to the patient. When the ligature is applied, the part having been well insulated, and effectually strangled by stout whipcord ligatures, sloughs and separates in a few days.

A modification known as the *elastic ligature* was introduced into practice by Dittel some years ago. It consists of a thin band of indiarubber, which is tied round the mass to be removed, and gradually tightened as it cuts its way through. It is possible that such a means may be useful in certain small pedunculated growths, which dry on being strangled ; but its application to large tumours, as of the breast, is simply a revival of mediæval barbarism with the aid of modern appliances. The slowness of its action, the pain as it cuts through, the large wound that is left, the fœtor from the necrosed tumour, and the chance of septic infection from this cause, all tend to make it a method that should be avoided whenever the knife can be employed. Far more tedious, and certainly not safer than the knife, it is also inferior to caustics, which at all events arrest putrefaction, and many of which, as chloride of zinc, have a powerful antiseptic action.

CHAPTER XXXV.

SCROFULA AND TUBERCLE.

Scrofula is a constitutional condition predisposing to chronic inflammation of a peculiar type, affecting various parts or tissues. **Tubercle** is a growth of a new tissue, also presenting peculiar anatomical and vital characteristics. The relation between the constitutional condition called scrofula and the development of tubercle has formed an endless subject of discussion, and is still very far from being determined. In discussing these affections, it will be most convenient to consider first the anatomical character of tubercle, and of some of the typical affections universally regarded as scrofulous.

TUBERCLE.—The anatomical structure which is generally recognized as characteristic of tubercle is the tubercular nodule, or follicle, as it has been called. This consists of a rounded mass of cells in which three zones can be usually recognized without difficulty. In the centre are one or more large many-nucleated cells, with more or less well marked branching processes—the so-called "giant-cells" of tubercle. The nuclei are most commonly arranged round the outer border of the cell, or may be collected together at one end; they are large and clearly defined, of oval form, and contain one or two nucleoli. The protoplasm is coarsely granular. The next zone is composed of large cells, with granular protoplasm containing a single clearly defined oval nucleus, similar to those of the giant-cell. These cells are called epithelioid, from their resemblance to young squamous epithelium. They lie between the processes of the giant-cell. The outer zone is composed of ordinary lymphoid corpuscles, differing in no respect from the migrating leucocytes observed in inflammation. Between the cells of the outer zones is an imperfect reticular stroma, with which the processes of the giant-cell are said to be continuous. No vessels penetrate amongst the cells, and this want of vascularity forms one of the most important and distinctive features of tubercle. A single nodule, such as has just been described, forms a small rounded body just visible to the naked eye; it is semi-transparent and grey in colour, and of cartilaginous hardness, and has received the name of the **semi-transparent grey granulation**. By an increase in the zone of lymphoid cells, or by the close apposition of two or more separate nodules, the grey granulations frequently reach the size of a millet seed, and have consequently received also the name of **miliary tubercles**. This structure has long been recognized as that most characteristic of tubercle, but none of its individual elements are peculiar to it. The lymphoid cells differ in no respect from those met with in simple inflammation, and large cells, like the epitheloid

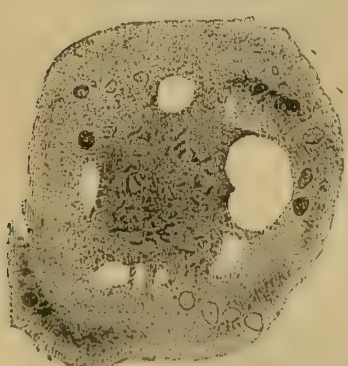


Fig. 409.—Tubercle Bacilli in a Giant-cell.

cells and giant-cells, are met with in simple chronic inflammatory processes. Ziegler and Tillmans have shown that similar cells are produced when granulation tissue is made to grow between the thin glass slides inserted into the peritoneal cavity, or beneath the skin of a rabbit.

In 1882, Koch discovered the fact, that in the tubercular nodules a specific microscopic organism, to which he has given the name of **bacillus tuberculosis**, is constantly met with. The bacillus is about equal in length to one-third of the diameter of a red blood corpuscle, and its breadth is about one-fifth of its length. Clear bright dots are seen in it which are believed to be spores. The bacilli lie within and between the cells, more especially in the giant-cells (Fig. 409). They may be single or grouped in masses. The discovery of these organisms by Koch was owing to the fact that they are permanently stained by various aniline dyes, which fail to affect the surrounding tissues, and they are thus readily recognized. They are most abundant in recent tubercle, and more scanty in the older nodules. The relation of these organisms to tubercle will be discussed further on.

The origin of the cells of tubercle is still uncertain. The lymphoid cells are believed to be chiefly or entirely migrating white corpuscles. The epithelioid cells are variously attributed to a further development of the lymphoid corpuscles, or to a growth from the lymphatic endothelium, or the connective tissue corpuscles of the part. The origin and nature of the giant-cells is still a matter of dispute ; they have been supposed to arise by the fusion of smaller cells ; by the failure of a growing mass of protoplasm to divide, apparently from want of energy, by proliferation of the endothelium of a lymphatic vessel, or of a blood-vessel, and lately Treves has asserted that they are merely lymph-coagula enclosing some of the smaller cells. It is not the place here to discuss these theories, but it may be stated that it is most probable that they arise either from fusion of smaller cells or from failure of a growing mass of protoplasm to divide. They are certainly the oldest part of a tubercle nodule, being situated in its centre, and often showing degenerative changes before the surrounding cells ; yet it has never been shown that they appear independently of the surrounding lymphoid corpuscles, and cells of various sizes are found intermediate between them and the lymphoid corpuscles. It is therefore most probable that they are derived from the lymphoid or epithelioid corpuscles by one of the processes above mentioned.

Anatomical Seat of Tubercle.—Tubercle has been described as originating always in pre-existing lymphoid tissue, such as exists abundantly in the submucous tissue of the bronchi and intestines, or in the lymphatic glands. It has been described as growing also in connection with the walls of small arteries, in lymphatic vessels, and in peri-vascular lymph spaces. The exact structure in which it develops is therefore uncertain, and is probably not always the same. It certainly arises in parts in which no lymphoid tissue is normally present.

Subsequent Changes in the Tubercle-Nodule.—The changes thus take place in the tubercle-nodules after they have reached a certain size form a characteristic feature of the growth, as important as their histological structure. Tubercle differs from simple inflammatory products in being incapable of higher development ; it invariably degenerates. The form of degeneration is almost always caseation or fatty degeneration. Before the nodule has reached much beyond the size of a millet-seed, its central parts

become yellow. Fat granules appear first in the cells, and subsequently in the stroma, till all trace of the cellular structure is lost, and the whole mass loses its grey semi-transparent appearance, becoming opaque and yellowish-white in colour, and soft and friable in texture. It is then known as **Yellow Tubercle**. The lymphoid corpuscles in the early stages of degeneration become shrunken and of irregular form. These withered cells were described by Lebert as tubercle-corpuscles, and were at one time considered to be characteristic. After caseation is complete, one of three changes may take place: first, the nodule may soften, inflammation and suppuration may take place in the tissues around it, and it may be expelled as a foreign body; secondly, it may become drier, and lime-salts may be deposited in it, or in other words, it may become calcified; and thirdly, it may become surrounded by a dense capsule of fibrous tissue, such as forms round a shot or bullet impacted in the soft parts, and in this way may remain harmlessly imbedded. Nélaton describes a bony capsule surrounding old grey granulations in the cancellous tissue of bone in cases of recovery from tubercular disease.

Caseation and the subsequent changes form infinitely the most common form of degeneration in tubercle, but occasionally it undergoes a fibroid change. The cells wither, while the stroma gradually thickens, and thus a small dense fibrous nodule may remain in the site of the grey granulation. Whether tubercle is ever absorbed, is a disputed point that it is needless to enter upon here; that it can become harmless and inactive is well known. This may occur either from fibroid degeneration, calcification, or encapsulation.

Extension and Growth of Tubercle.—The extension of tubercle may take place by the development of new nodules in contact with that first formed, which in their turn undergo fatty degeneration, till caseous masses may be formed of considerable size. The large masses of yellow tubercle thus formed were at one time regarded as the most characteristic form. The edge of the mass may be surrounded by a zone of reddish-grey translucent tissue. This is often very well seen in tubercular disease of the testicle. Here a yellow caseous mass is sometimes met with, an inch or more in diameter, involving the epididymis, and extending into the body. At the advancing edge there may be a zone one-sixteenth of an inch in width, semi-transparent, reddish-grey in colour, and firm in texture. Microscopic examination shows this to be composed of ordinary granulation-tissue with giant cells, and the surrounding groups of epithelioid cells scattered through it, the lymphoid corpuscles being indistinguishable from the surrounding inflammatory new growth. (See Diseases of Testicle, vol. ii., Figure illustrating tubercular testis.)

In other cases fresh grey granulations appear dotted around the original nodule amongst tissues apparently healthy. These two modes of spreading might be described as continuous and discontinuous local infection.

The next mode of extension is from the original seat of development to the neighbouring lymphatic glands. The gland becomes enlarged, caseous patches appear in it, and the microscope shows numerous tubercle-nodules scattered through it.

Lastly, general infection may take place, grey granulations appearing throughout the body, in the viscera, serous and mucous membranes, bones, and

occasionally in the synovial membranes. The skin, muscles, and peripheral nerves are seldom if ever infected. The general infection may be acute or chronic.

The appearance of tubercle is spoken of as *tuberculosis*; thus we have local tuberculosis and general tuberculosis, the latter being either acute or chronic. General infection not unfrequently follows suddenly after the process has remained local for a considerable time. Thus tubercular testicle may remain a local affection for many months, and terminate suddenly by acute general infection.

The Nature of Tubercle.—The growth of tubercle is now generally regarded as a peculiar modification of inflammation. From what has already been said, it will be at once seen that it belongs to the class of infective inflammations. The nature of the virus upon which it depends, is still a matter of discussion. Koch believes that he is justified in assuming that the bacillus tuberculosis is the actual virus of tubercle, just as the bacillus anthracis is of splenic fever or malignant pustule. The bacillus anthracis gives rise, as we have already seen (p. 361), to a specific inflammation of a peculiar character, which remains local for a certain time, but ultimately infects the whole system. So tubercle may commence as a local affection, and finally infect the whole system. Splenic fever is, however, an acute process, the progress of which is measured by days ; tuberculosis is a mere chronic process lasting months or years, and sometimes never passing beyond the local stage. In support of the theory that the bacillus is the actual virus of tubercle, Koch has made numerous experimental investigations which have been fully confirmed by subsequent observers. It had long been known as the result of the observations of Villemin, Wilson Fox, Burdon-Sanderson, Cohnheim, and many others, that the inoculation of tuberculous matter from the human subject or other animals into rabbits or guinea-pigs gives rise to general tuberculosis in the animal experimented on. Koch, in order to show that the bacillus is the actual virus, cultivated it in blood-serum, and found that the true tuberculosis could be induced by the inoculation of the bacillus many generations removed from the original stock. He therefore believes that the bacillus itself, and not any product of caseating tubercle, is the true virus. He would make the presence of the bacillus the test of the tubercular nature of any caseating mass of inflammatory products. His theory of tuberculosis would, therefore, be—that the specific virus in the form of the bacillus or its spores enters the system by the lungs or alimentary canal. If the patient is predisposed to the reception of the poison, either from hereditary tendency or an acquired condition resulting from bad hygienic surroundings, want of proper food, debilitating disease, &c., it may infect the part at which it enters, the lungs or alimentary canal, or, these escaping, it may enter the blood, and lodge at some part weakened by injury or by previous disease, as in a joint or bone, or the epididymis, or in a chronically inflamed lymphatic gland, and then develop, setting up the peculiar form of chronic inflammation which results in the caseating tubercle-nodule. In a perfectly healthy subject it may be eliminated or destroyed without developing. Thus, granting the theory of the mycotic origin of tubercle, it is still necessary that the soil and the conditions necessary for the development of the fungus should be present. Much further evidence is still required before the whole of these theories can be accepted, especially with regard to those diseases of bones, joints, and lymphatic glands, which come

under the care of the Surgeon, and were formerly classed as simply scrofulous, but are now regarded by many pathologists as tubercular.

Inflammation Consequent upon the Development of Tubercle.—In general tuberculosis the deposit of tubercle is frequently followed by a diffuse inflammation of the surrounding tissues. The best example of this is the diffuse inflammation of the membranes of the brain which occurs in tubercular meningitis. In what way the formation of the grey granulations excites the acute inflammatory process in the surrounding parts is uncertain.

When a tubercular nodule or a mass of yellow tubercle softens, it excites inflammation and suppuration in the surrounding tissues. The process is usually a chronic one ; a collection of pus slowly forms in the affected part, and a chronic abscess results. When this reaches a surface and is opened or bursts, pus containing curdy shreds of fatty granular matter escapes, and the walls of the cavity are found to be of a yellowish colour, with ragged flocculi of softened caseous matter adherent to them. A section through such a wall may show the surrounding tissues studded with grey granulations in various stages of caseation. Tubercular abscesses are most commonly met with in surgical practice in diseases of bones or joints, and in lymphatic glands and the testicle. If the tubercle become formed in the submucous tissue of a mucous membrane, an ulcer is left after the softened mass has been discharged. The floor of the ulcer is yellow and granular, the base slightly indurated, and the edges raised and sometimes undermined. The tubercular ulcer tends slowly to spread, the base and edges becoming progressively infiltrated by fresh tubercle, which in its turn caseates, softens, and is discharged. Such ulcers are chiefly met with in surgical practice in the bladder, rectum, and tongue. They are common also in the larynx. When softened tubercle becomes exposed to the air, the inflammation surrounding the diseased focus may be aggravated and hastened by decomposition of the discharges.

Scrofula or Struma.—Scrofula is a constitutional condition characterized by a tendency to inflammation of a peculiar type. These inflammations arise from slight causes which would be innocuous to healthy subjects ; the course of the process is slow and feeble ; when affecting a mucous surface it tends to assume the form of chronic purulent catarrh ; in deeper parts the inflammatory products are abundant in quantity, have little tendency to develop into a higher tissue, but are prone to early degeneration and caseation, followed by softening, with the formation of thin, unhealthy, curdy pus. After suppuration has been reached the process tends to persist, and gradually to extend, giving rise to ulceration with progressive destruction of the affected tissue. After apparent recovery relapses are common, the feeble cicatricial tissue breaking down, and the destructive inflammation beginning again.

The nature of scrofulous or strumous inflammations will be made more clear by briefly describing some of the more common forms as they appear in different structures.

In the **Skin** scrofula declares itself by a variety of cutaneous eruptions : of these, eczema is one of the most common, and it tends to be complicated by suppuration, forming the eczema impetiginodes so common on the scalps of scrofulous children.

Another common form of skin affection is the *subcutaneous strumous abscess*. This arises as a small, flat, indurated growth, commencing immediately beneath the cutis vera. The patch slowly extends till it reaches the size of a sixpence

or shilling, or even larger. The skin covering it is of a dusky purple in colour. Finally the mass softens, the skin gives way at one spot, and a thin curdy pus is discharged. The cavity left is covered superficially by a thin layer of undermined skin, of a dark bluish colour, which is too feeble to undertake any process of repair, but yet obtains just enough blood-supply to prevent its death. Consequently no healing will take place till it is destroyed. After this has been done the floor of the ulcer will be seen to be yellow and unhealthy, and the sore may slowly spread instead of healing. The original mass is composed of a mass of small round cells, amongst which may be giant and epithelioid cells. It is imperfectly vascularized, and very early undergoes fatty degeneration, followed by softening.

The scrofulous sores of this kind are most common on the face, but they may occur in other parts of the body (Fig. 410).

Fig. 410.—Scrofulous Ulcer of Leg.

Some forms of *lupus* are also supposed to be due to scrofula.

The **Mucous Membranes** are commonly extensively affected, and often present the earliest forms of scrofulous disease in childhood ; this is more especially the case with those of the eye, nose, and ears. The *conjunctiva* becomes chronically inflamed, and the discharge becomes muco-purulent. As a sequela of this the condition known as "granular lids" not uncommonly is set up. The papillæ become excessively vascular and hypertrophied, till the whole surface of the membrane appears to be covered with genuine granulation-tissue. The affection specially known as strumous or phlyctenular ophthalmia, consists of the formation of a small, intractable ulcer on the cornea, with intense injection of the surrounding conjunctiva.

The *mucous membrane lining the nostrils* becomes chronically congested, red and swollen, giving rise to habitual sniffing and to a sensation as of a constant cold. The discharge, at first merely mucous, frequently becomes purulent, and lodging in the irregularities of the nasal fossæ, decomposes, giving rise to the most offensive smell. This condition, known as *strumous ozæna*, may sooner or later cause ulceration of the membrane and subsequent necrosis of the bones. Occasionally the lining membrane of the antrum becomes irritated, and this may be followed by enlargement of the cavity and discharge of unhealthy pus into the nostrils.

Chronic purulent discharge from the ear, *scrofulous otorrhœa*, is another very common affection. The disease most frequently commences in the middle ear, the discharge finding its way out by perforating the membrana tympani. It frequently leads to destruction of the ossicles and permanent deafness. The mucous membrane of the *genito-urinary organs* also is readily affected with purulent catarrh, often arising from very slight causes and very permanent. Such discharges are of common occurrence in female children, and have frequently given rise to unfounded charges of criminal assault.

Perhaps the most important local diseases arising under the influence of scrofula are those of the **Bones and Joints**. The bones are liable to a slow pro-

cess of ulceration or caries, usually commencing in their articular ends or cancellous tissue. The bony tissue becomes invaded and destroyed by an advancing growth of small round cells, amongst which will usually be found giant-cells, epithelioid cells and lymphoid corpuscles, arranged as already described in tubercle-forming non-vascular areas amongst a fungating mass of vascular granulation tissue. The inflammatory products tend to early degeneration and softening, and chronic abscesses containing unhealthy curdy pus are formed. This condition is especially prone to occur in the spongy tissue of the articular ends of long bones or in the cancellous tissue of short bones, more particularly the vertebræ and the bones of the foot. When the disease extends from the bones into a neighbouring joint, a chronic inflammation of a similar character springs up in the whole synovial cavity, giving rise to the condition known as *white swelling*. The membrane becomes covered by a mass of fungating granulation-tissue, scattered through which nodules are usually met with identical in structure with those already described under tubercle. In other cases the chronic inflammatory process commences in the synovial membrane and secondarily affects the bones. Necrosis of the compact tissue of long bones is also frequently ascribed to the constitutional taint of scrofula; and the process above described is often complicated by death of considerable portions of the cancellous tissue.

Another common scrofulous affection of bone is that known as *strumous dactylitis* (Fig. 411). It is of frequent occurrence in children. One or more phalangeal or metacarpal bones become gradually enlarged. The medullary canal becomes distended with chronic inflammatory products, the compact tissue is absorbed and a fresh layer deposited from the periosteum, and thus the bone becomes "expanded." The inflammatory products caseate, then soften, and finally form unhealthy curdy pus, which slowly makes its way to the surface and is discharged.

Fig. 411.—Scrofulous Diseases of Finger and Arm.

Secreting Glands are less frequently affected by scrofulous inflammations. The testicle perhaps most commonly suffers; a large mass of caseating inflammatory products slowly forming in connection with the epididymis.

Lastly, the **lymphatic glands** are peculiarly prone to scrofulous disease; in fact, the affections of the glands are usually looked upon as the most constant and characteristic feature of scrofula. It is not, however, only the glands that suffer; wherever lymphoid tissue exists, as in the follicles of the tonsil and pharynx, or in the submucous tissue of the bronchi and intestines, it tends to undergo hypertrophy in strumous subjects. The enlargement of the glands in scrofulous subjects can almost always be traced to some irritation at the part from which they receive their lymph supply. In the mildest form the gland simply enlarges, and may after a time subside or be left permanently larger and harder than natural. In most cases, however, there is distinct chronic inflammation, and the gland becomes greatly increased in size. This is found to be due to an increase of lymph-corpuscles and to

inflammatory exudation. The central parts caseate and afterwards soften. Suppuration takes place, first within the gland and subsequently external to it beyond its capsule ; and the abscess thus formed slowly reaches the surface, often extensively undermining the skin before discharging, unless this be prevented by early opening. Microscopic examination of a gland when undergoing caseation shows the presence of numerous giant-cells, surrounded by the zones of epithelioid and lymphoid corpuscles such as have already been described as forming the anatomical characteristic of tubercle.

Strumous glands may be met with at any part of the body, but they are by far more common in the neck than elsewhere. Treves states that in 155 cases examined by him in the Margate Infirmary, the neck alone was affected in 131, the neck and axilla in twelve, groin alone in 6, axilla alone in 4, neck and groin in 1, and groin and axilla in 1.

All the affections just described, which are by common consent termed scrofulous or strumous, possess therefore in common the characters already pointed out ; they arise from causes which would be harmless in a healthy subject ; they run an extremely chronic course ; they tend to assume the form of purulent catarrh of surfaces, and of chronic inflammation, with caseation of the inflammatory products, in deeper structures.

Relation of Scrofula to Tubercle.—We are now in a position to consider the relation of the constitutional condition known as scrofula to the pathological product known as tubercle. If we are to take the tubercle-nodule or follicle as the characteristic of tubercle, it will be seen from what has just been stated that many of these so-called scrofulous affections also must be classed as tubercular. In the caseating mass which precedes the subcutaneous scrofulous abscess ; in the fungating granulation-tissue of scrofulous caries or white swelling ; in the cheesy inflammatory products in strumous dactylitis ; in the so-called strumous testicle, and in scrofulous lymphatic glands, non-vascular nodules indistinguishable from those met with in a grey granulation are constantly or almost constantly present. Many of these affections after remaining local for a long time are followed by general tuberculosis. The reports of University College Hospital show that in 67 fatal cases of strumous diseases of different kinds occurring in the surgical wards, tubercle was found in the lungs or disseminated throughout the body in 17, or almost exactly 25 per cent. These 67 cases include, 9 of necrosis of various bones, 21 of caries of the spine, 14 of disease of the hip, 9 of disease of the knee, 3 of the elbow, 2 of the wrist, 2 of the sacro-iliac joint, 1 of the shoulder, 1 of caries of the temporal bone, 1 of caries of the os calcis, 1 case of otitis media, 1 of scrofulous testicle and 2 of scrofulous kidney. Of course the fatal cases form but a small proportion of the whole number admitted. The results, however, form a marked contrast to those of the post-mortem examinations of cases dying from other surgical diseases. If we exclude four cases of pulmonary phthisis, in which the lung disease was primary and surgical affection merely an accidental complication shortly before death, we find that in 561 cases active tubercular disease was met with only in 10. If we exclude the cases of injury and acute disease, we find that in 158 deaths from various chronic surgical affections, active tubercular disease of the lungs was met with in 7, or 4·4 per cent.

If we accept the views of Koch, that the only absolute characteristic of tubercle is the presence of bacillus tuberculosis, we have further evidence that many diseases classed as scrofulous are accompanied by the development of

true tubercle. The bacillus has been found in the pulpy granulation-tissue of white swelling, in scrofulous glands, and in the scrofulous testicle and kidney. It is impossible, therefore, to deny that true tubercle makes its appearance in the inflammatory products during the course of many scrofulous inflammations, but it by no means necessarily follows that all scrofulous affections are tubercular, or that when tubercle is met with it is the primary cause of the mischief. The purulent catarrhal affections and the skin eruptions which are such frequent manifestations of scrofula, are certainly not tubercular. In a considerable number of cases of caseating inflammations of glands and bones in which a careful search has been made for the bacillus it has not been found. There is no doubt also that only a small minority of patients who suffer from scrofulous diseases of glands, bones or joints, die of pulmonary phthisis, and the converse is equally true, that the vast majority of phthisical patients show no signs of any of the surgical affections ordinarily classed as scrofulous. It is equally certain, however, that phthisical parents may have scrofulous children, and the offspring of scrofulous parents frequently die of consumption. There can be no doubt, therefore, that the relation between scrofula and tubercle is a very intimate one.

The following hypothesis has therefore been suggested as capable of harmonizing the apparently conflicting facts above stated: that scrofula is a constitutional vice characterized by a peculiar proneness of the tissues to be affected by chronic inflammation from slight causes, or as Virchow expresses it, by a vulnerability of the tissues; that simple scrofulous inflammations are not in themselves infective, but that they tend to persist indefinitely, being kept up by very slight sources of irritation, as tension from inflammatory exudation, slight degrees of friction or movement and the like; consequently the inflammatory products accumulate, and from the feebleness of the whole process are imperfectly vascularized, and have but little power of higher development or resorption; lastly, that these inflammatory products form a suitable nidus for the development of the specific virus of tubercle, and that by the entrance of this virus the process becomes infective; it may then remain a local infective process, and even cease without becoming general, or it may infect the whole system, giving rise to acute or chronic general tuberculosis.

Signs of Scrofula, or the Scrofulous Diathesis.—The only certain signs of scrofula are the various forms of inflammation already described, but the individuals in whom the affections arise usually present certain constitutional peculiarities which are said to be indications of the **scrofulous diathesis.** The constitutional condition is often erroneously confounded with general debility. It may, and often does, co-exist with this, but is by no means synonymous with weakness of constitution. Debility often exists without any scrofulous tendency or taint, more particularly in individuals of the nervous temperament; many delicate people, though weak, being perfectly healthy, and showing no disposition to strumous affections; on the contrary, the scrofulous constitution is often conjoined with much muscular power and mental activity.

The existence of the scrofulous diathesis is often marked by the presence of a peculiar temperament.

The **Scrofulous Temperament** assumes two distinct forms, the fair and the dark, and each of these presents two varieties, the fine and the coarse. The most common is that which occurs in persons with fair, soft, and trans-

parent skin, having clear blue eyes with large pupils, light hair, tapering fingers, and fine white teeth ; indeed, whose beauty is often great, especially in early life, being dependent rather on roundness of outline than on grace of form ; and whose growth is rapid and precocious. In these individuals the affections are strong, and the procreative power considerable ; the mental activity is also great, and is usually characterized by much delicacy and softness of feeling, and vivacity of intellect. Indeed, it would appear in such persons as these, that the nutritive, procreative, and mental powers are rapidly and energetically developed in early life, but become proportionately early exhausted. In another variety of the fair scrofulous temperament, we find a coarse skin, short and rounded features, light grey eyes, crisp and curling sandy hair, a short and somewhat ungainly stature, and clubbed fingers ; but not uncommonly, as in the former variety, great and early mental activity, and occasionally much muscular strength.

In the dark form of the scrofulous temperament, we usually find a somewhat heavy, sullen, and forbidding appearance ; a dark, coarse, sallow, or greasy-looking skin ; short, thick, and harsh curly hair ; a small stature, but often a powerful and strong-limbed frame, with a certain degree of torpor or languor of the mental faculties, though the powers of the intellect are sometimes remarkably developed. The other dark strumous temperament is characterized by clear dark eyes, fine hair, a sallow skin, and by mental and physical organization that closely resembles the first described variety of the fair strumous diathesis.

In all these varieties of temperament, the digestive organs will be found to be weak and irritable. This condition, which I believe to be invariably associated with struma, and the importance of which has been pointed out by Sir James Clark, must be regarded as one of the most essential conditions connected with scrofula, and as tending greatly to that impairment of nutrition which is so frequent in this state. This gastric irritability is especially characterized by the tongue, even in young children, being habitually coated towards the root with a thick white fur, through which elongated papillæ project, constituting the "pipped" or "strawberry" tongue ; the edges and tip, as well as the lips, being usually of a bright red colour. This state of the tongue is aggravated by stimulants, high living, and the habitual use of purgatives. In the fair varieties the bowels are usually somewhat loose, but in the dark forms of struma there is a torpid condition of the intestinal canal. In all cases the action of the heart is feeble, and there is a tendency to coldness, and often to clamminess of the extremities.

Although these peculiarities of temperament are commonly observed in strumous subjects, yet cases of scrofulous disease are very frequently met with in patients who present none of them.

After the definite manifestations of scrofula have made their appearance the general health usually suffers considerably. The individual usually emaciates, becomes sallow, cachectic and debilitated. The prolonged suppurations accompanying many scrofulous affections are frequently accompanied by hectic or by amyloid degeneration of the liver and other viscera.

In scrofulous patients it is comparatively uncommon to meet with more than one of the graver manifestations of the diathesis in the same case. Treves states that of 509 cases of scrofula obtained from the records of the Margate Infirmary, in only 56 did the patient exhibit more than one gross mani-

festation of the disease; those cases being excluded in which glandular affection was evidently secondary to the primary local disease.

Signs of General Tuberculosis.—The consideration of this subject belongs to Medicine rather than Surgery. When general tuberculosis occurs as a secondary consequence of a local scrofulous disease it most commonly appears in the form of ordinary pulmonary phthisis, and runs the usual chronic course. Progressive emaciation, evening elevation of temperature and night sweats, which cannot be accounted for by prolonged suppuration from the local seat of disease, always lead to a grave apprehension that general tuberculosis is taking place.

In cases of acute general tuberculosis following a local scrofulous disease, such as are occasionally met with in joint-disease and more often in scrofulous or tubercular testicle, there is marked febrile disturbance, the thermometer reaching often 103° F. or 104° F., without, at first, definite affection of any organ. The symptoms may then closely resemble typhoid fever, or if there is an open wound, may be mistaken for septicæmia. Before long, usually not later than the second week, symptoms either of acute pulmonary phthisis, tubercular meningitis, or some other definite tubercular affection, make their appearance.

Causes.—The causes of scrofula and tubercle, unless these be of a hereditary character, though very various in their nature, are usually such conditions as influence injuriously the nutrition of the body.

The *Hereditary Nature* of both scrofula and tubercle is well known to the public and to the profession; for, although the disease is not commonly connate, yet the tendency to it is, and the characteristic nature of the affection often manifests itself at an early period. That a parent may transmit a tendency to malnutrition, just as he may a peculiar feature or mental condition, is undoubted. There are certain conditions which, though not scrofulous, are supposed to have a tendency to develop this disease in the offspring to which they are transmitted; thus, very dyspeptic parents commonly have strumous children; so, also, the offspring of very old or very young people often exhibit a proneness to scrofulous or tuberculous affections. The influence of intermarriage is still a matter of doubt, but I believe that it is but small; and it is commonly stated that the inhabitants of small communities who intermarry closely, such as those of the Isles of Portland and of Man, are not more liable to scrofula than other individuals.

The most powerful occasioning cause of scrofula, and that which in most civilized countries is likewise the most frequent, is *malnutrition* and *mal-assimilation* arising from an habitual disregard of hygienic laws; either from insufficiency of nourishment, or the administration of improper food, in the poorer classes; or from overfeeding, and overstimulation of the digestive organs, amongst the children of the wealthier orders of society, inducing chronic irritation of the mucous membrane of the stomach and interference with the digestive powers, and consequently with nutrition. The influence of food that is innutritious in quality or insufficient in quantity, has been shown by Phillips, in his excellent *Treatise on Scrofula*, to be the most immediate cause of this disease; and, when conjoined with the injurious effects of a confined and impure atmosphere, it may be considered as sufficient to occasion the disease in those cases in which no predisposition to it exists, and greatly to develop any hereditary tendency to it in the system. It is to the conjoined

influence of agencies such as these that we must attribute the prevalence of scrofula amongst the lower orders both of town and of rural populations.

Both scrofulous and tuberculous manifestations are often called into immediate action by the *debility induced by previous diseases*, such as measles, scarlatina, hooping-cough, &c.

The *inoculability* of tubercle has been fully established by the experiments of Villemin, Wilson Fox and Burdon-Sanderson, and the recent observations of Robert Koch have suggested that the bacillus discovered by him is the actual virus. What part *infection* plays, however, in the causation of tubercle is still undetermined. That infection of the system may take place from a local focus of tubercular inflammation is beyond a doubt; and there is strong evidence in support of the belief in the transmission of the disease from individual to individual by close cohabitation, social or sexual. Yet, however great the part played by infection may be, it is beyond a doubt that the virus requires a proper soil for its development, and that the body of a healthy individual does not furnish that soil. In the prevention of the disease it is therefore to the constitutional predisposing causes that our attention must be chiefly directed. The possibility of general infection from a local focus of disease suggests also the importance of the removal by operation of all old tuberculous masses in glands or bones, lest they become centres of tuberculous dissemination.

Excluding diseases of the lungs, scrofula usually develops at *an early age*, though seldom before the child has reached its second year. It is most commonly about the period of the second dentition that the affection declares itself, and it is rare to meet with it for the first time after the ages of twenty-five or thirty-five. According to Phillips, when it is fatal, it usually proves so before the fifteenth year; 60 to 70 per cent. of the deaths occurring before this age. *Sex* does not appear materially to influence the disease; though, according to the same authority, the deaths of males from scrofula exceed those of females, in this country, by 24 per cent.

Senile Scrofula.—Middle-aged and elderly people are occasionally attacked by an acute form of scrofulous disease. The individuals so affected have usually been tuberculous in their youth, or come of strumous families. But the disease has apparently been cured, and they may have enjoyed good health and led active lives for a long series of years. Under the influence of depressing physical or mental causes, or as the result of debility and ill health consequent on some serious illness, typical symptoms of scrofulous disease will manifest themselves in the soft parts, the joints, and the bones. The disease may run an acute course, and the patient will die of tuberculosis of some of the organs.

Treatment.—This should consist rather in endeavouring to prevent the occurrence or full manifestation of scrofula, than in removing it when it is actually existing. Indeed, the **Preventive Treatment** is perhaps of most consequence, and by proper attention to it, I have no hesitation in saying, the development of the affection, even when hereditary, may be stopped; and the child of strumous parents, presenting perhaps the features indicative of the diathesis, may pass through life without the disease having an opportunity of declaring itself. In order to accomplish this, however, the preventive plan of treatment must be commenced early, and continued uninterruptedly for a considerable time, even for years.

The preventive treatment of scrofula and tubercle may be said in general terms to consist in close and continuous attention to hygienic rules. The diet must be specially attended to; nourishing food, but of the lightest quality, being given. A great error is often committed in overloading the stomach with more or with heavier food than it can digest, under the impression that strong food is necessary to give the patient strength. In consequence of this error, the irritability of the mucous membrane is kept up, nutrition is imperfectly and badly performed, the surplus food is thrown off in the shape of lithates or other products of mal-assimilation, and health and strength, which are the results of perfect nutrition, become impaired rather than improved. The use of stimulants, whether wine or beer, should be very sparing, and the milder and weaker should be preferred to the heavier and stronger kinds of malt liquor; the bowels must be kept regular with the simplest aperients; the clothing should be warm, and must cover the whole of the surface; and the patient should, if possible, be kept in well-ventilated rooms. He should be allowed sufficient exercise in the open air, not carried to the point of fatigue, and should, if his circumstances will permit, have change of air from time to time, alternating a sea with an inland climate. Bathing also, whether in sea or river, with the habitual use of the tepid or cold sponge-bath, and friction of the surface with horse-hair gloves or a rough towel, so as to keep the skin in healthy action, should be regularly practised. In carrying out this general plan of treatment, it must be borne in mind that the health and strength of a delicate and weakly child can be improved only up to the highest standard admissible by its individual constitution. A weakly, scrofulous child may be improved in health and may be strengthened in body; but it can never, by any hygienic, dietetic, or medicinal process, have the original defect in its organization so completely eradicated as to be rendered as robust and vigorous, as a child of good congenital stamina who had been equally well cared for.

The **Curative Treatment** should be specially directed, like the preventive, to the general improvement of the nutrition, and through it to the augmentation of the constitutional vigour of the patient; all those hygienic means that have just been alluded to being continuously carried out.

The more strictly medical treatment of scrofula consists in the administration of tonics and alteratives with the view of improving the patient's constitutional powers. Before they are administered, however, it is always necessary to see that the digestive organs are in a healthy condition. Scrofula is a consequence of malnutrition; and unless we see that digestion, the first stage of the nutritive process, is properly accomplished, all other means will be useless. When the tongue is covered with a white, thick, creamy fur, and has elongated papillæ and red edges, the mucous membrane being in a state partly of irritability and partly of debility, neither purgatives nor tonics can be largely administered: the former irritating, the latter overstimulating the morbidly sensitive mucous membrane. In these circumstances the patient should be confined to the mildest possible diet, which must principally consist of milk, boiled fish, white meats, and light pudding, no stimulant of any kind being allowed except a small quantity of claret or bitter beer; and, unless the patient have been accustomed to the use of stimulants, these even had better be dispensed with. Small doses of mercury with chalk, of soda and rhubarb, should be occasionally administered at bed-time, with some of the compound decoction of aloes on the following morning; and a few grains of the carbonate of soda or of potash

may be given twice or thrice a day in some light bitter infusion, as of cascarilla or calumba. In many cases of strumous disease, more especially those affecting the joints and bones, the liver will be found to be enlarged and sluggish in its action, the patient every now and then becoming bilious, sallow, and jaundiced; in these circumstances, small doses of blue pill, carried off with the compound decoction of aloes or a rhubarb draught, will be found necessary from time to time. When all gastric irritation has been removed in this way, or if it have not existed in the usual marked degree from the first, the patient being pale and flabby, with a weakened condition of the pulse, of the skin, and of the mucous surface, then tonics may be administered, and the more specific treatment adopted.

The great remedies which are employed with the view of removing scrofula and curing the secondary affections which it induces, are iron, iodine, the preparations of potash, and cod-liver oil. These are all extremely useful, either singly or conjoined, as they serve to carry out distinct indications in the management of this affection.

Iron is most useful in improving the nutrition of pale, flabby, anæmic subjects, increasing markedly the quantity and quality of blood in the system. The best preparations for children are, I think, the vinum ferri and the syrup of the iodide of iron. In older persons the tincture of the perchloride, and some of the forms of the citrate or the phosphate of iron, appear to be most serviceable; in other cases, again, the natural chalybeate waters will be found to agree best.

Iodine is especially valuable in promoting the absorption of effused plastic matters, and in lessening the morbid hypertrophies which so commonly take place in scrofula. The preparation usually employed is the iodide of potassium. In order that this may produce its full effects, it should be given as freely as the patient will bear it, continued for a considerable length of time, and especially administered in combinations with other preparations of potash. With the view of preventing it from irritating the stomach, it should be given in a considerable quantity of some bland fluid. Its combination with the other salts often renders it more efficacious. For this purpose I have found the following form extremely useful for adults, the dose being proportionately diminished in the case of children:—℞ Potassii iodidi, Potassæ chloratis, āā ʒj; Potassæ bicarbonatis, ʒiij. Divide into twelve powders, of which one is to be taken night and morning in half a pint of warm milk. In other cases, the liquor potassæ, Brandish's alkaline solution, or lime-water given freely in milk, are serviceable; but I prefer the above prescription.

Cod-liver oil, which may be looked upon rather as an article of diet than as a medicine, is of essential utility in improving the nutrition of the body in cachectic and emaciated states of the system, more particularly in growing children, or in individuals who are suffering from the wasting effects of strumous suppuration; it not only fattens but strengthens the system, increasing decidedly the muscular power and the quantity of red corpuscles in the blood. It may often very advantageously be administered in combination with the iodides of potassium or iron, and given after meals.

Of the other tonic remedies which may be employed in this affection, such as the preparations of *bark* and of *sarsaparilla*, I need say nothing beyond that they may often be usefully administered in fulfilling ordinary therapeutic indications. Ringer recommends the *sulphide of calcium* as extremely valuable

in scrofulous and tuberculous glands, and in chronic strumous sores and abscesses. He uses it in a solution which has much the strength of Harrogate Waters. Thus, he directs a grain of the sulphide of calcium to be dissolved in a half pint of water, and of this a teaspoonful is taken every hour. As this mode of administration is seldom practicable, the drug may be given in small doses from three to six times a day. The best form is in pilules containing from one quarter to half a grain. If these cannot be obtained, the finely powdered sulphide may be kept in a closely stoppered bottle, and enough just to cover the point of a pen-knife taken in a wine glass of water. It cannot be made up in any mixture, as it rapidly decomposes, in contact with water giving off sulphuretted hydrogen. Under its influence, the glands, it is said, either return to the normal state or hasten on to suppuration, and chronic abscesses either dry up or are speedily brought forward and their contents discharged, a healthy healing sore being left.

The **Local Treatment** of scrofula consists in a great measure in the ordinary local management of chronic inflammation, modified according to the seat and peculiar nature of the affection. Much of the local treatment, however, especially in the more advanced stages, consists in removing the effects of the disease in the shape of caseous deposits, false hypertrophies, and general enlargement and thickening of parts.

The treatment of scrofulous abscesses must be carried out according to the rules laid down in the Chapter on Abscesses. Whenever caseous matter is present in the wall of the abscess, it should be scraped away by means of a sharp spoon (Fig. 95). By this means the patient is frequently saved the long suppuration which would otherwise attend its gradual expulsion. In these operations antiseptic treatment in some form is of the greatest value. In many cases the healing is apparently hastened by the introduction of a small quantity of iodoform into the cavity. Iodoform-wool also will be found one of the most convenient dressings. In some cases the injection of tincture of iodine into the sac of the abscess will be found very useful. The local treatment of scrofulous diseases of bones and joints will be fully discussed with the diseases of those parts.

Chronic thickenings left after scrofulous inflammations may be removed by means of lotions containing the iodide of potassium, or the carbonate of potash, applied by means of lint covered with oiled silk ; a drachm of each of the salts, with an ounce of spirits of wine to eleven ounces of water, makes an excellent application, which appears often to be very efficacious. In many cases, frictions with the iodide of lead ointment, or pressure by means of strapping and bandages, will be found the most serviceable means that the Surgeon can adopt.

Operations in Scrofulous and Tuberculous Cases.—In cases of scrofulous diseases of the soft parts, the bones, or the joints, the question of the propriety of operating, whether this be for the excision of a gland, the resection of a joint or bone, or the amputation of a limb, has often been discussed. In these cases, operations should not be undertaken too hastily, too early in the disease, or in very young subjects. The affection being constitutional, it will often be found, as the general health of the patient is improved by proper treatment, that local mischief, which at first appeared very intractable, gradually assumes a more circumscribed and healthy form, and, in fact, to a great extent undergoes spontaneous cure. This we especially find to be the

case in young children, in whom very extensive disease of the bones and joints may often be recovered from, without the necessity of any serious surgical interference. Should any operation be undertaken, it is desirable not to have recourse to it whilst the disease is actively spreading. In these circumstances, it is not only probable that suppurative inflammation of an unhealthy kind may be set up in the wound itself, but that disease of the soft parts or bones may recur in the cicatrix of the original wound, or that the corresponding parts on the opposite side of the body may become similarly affected in very chronic cases of scrofulous disease of bones and joints. After excision of the elbow, the knee, or the bones of the foot and wrist, the disease will sometimes return in the contiguous soft parts to such an extent as to render a second operation necessary; the tissues in the neighbourhood of the cicatrix becoming swollen, spongy, and infiltrated with a quantity of gelatinous semi-transparent exudation, running into unhealthy suppuration, with fistulous tracts leading through it that cannot be brought to heal. In some cases even of simple strumous disease of the integuments of the arm, leg, or foot, attended with chronic and intractable ulceration, amputation of the limb is the only course left to the Surgeon. When strumous suppuration leads to hectic, the patient will speedily sink unless the diseased structures be removed.

CHAPTER XXXVI.

VENEREAL DISEASES.

The term *Venereal Disease* is used to denote those affections which arise primarily from sexual intercourse. It was, until lately, held to include but two distinct specific diseases—Syphilis and Gonorrhœa. The special researches of Surgeons in this country and on the continent have, however, in late years, established the fact, that in the term Syphilis there have been included two distinct affections, both communicable by contagion during intercourse, but differing in their characters, and especially in this,—that the one is a purely local affection, while the other not only produces local effects, but, by the introduction of a specific poison into the system, infects the general constitution of the person to whom it is communicated. To the purely local disease the term Local Contagious Ulcer or Chancre may be applied; the word Syphilis being restricted to the constitutional affection. By some writers the term Chancre is limited to the non-infecting sore, but much more commonly it is applied also to that form of the primary manifestation of syphilis in which there is an ulceration at the seat of inoculation. When used in this way the different forms of sore are distinguished as infecting or non-infecting, syphilitic or simple, hard or soft chancres.

Hunter and his followers supposed that all the specific diseases arising from sexual intercourse originated from one and the same poison. But this doctrine has been proved to be erroneous; for not only are the local appearances and constitutional effects of these diseases widely different, but Ricord has shown, in the most conclusive manner, that gonorrhœal matter, when inoculated on the skin or mucous membrane, never produces a chancre; and that, on the other hand, chancrous pus can never be made to produce gonorrhœa. Each of the diseases—Local Contagious Chancre, Syphilis, and Gonorrhœa—propagates itself, and no other. Two of these diseases may, however, co-exist in the same person. Thus, we shall have occasion to notice the coincidence, in some cases, of the local chancre with the phenomena of constitutional syphilis. Again, Ricord has pointed out, that a woman may at the same time be affected by gonorrhœa and by chancres on the uterus; and this probably explains those cases in which, after connection with the same woman, different men have contracted different forms of disease, or even both affections. In this Chapter, we shall describe—1, the Local Contagious Ulcer or Chancre; and 2, Syphilis; reserving the consideration of Gonorrhœa till we speak of Diseases of the Urinary Organs.*

1. LOCAL CONTAGIOUS ULCER OR CHANCRE.

The **Local Contagious Ulcer, Simple Non-infecting Sore or Soft Chancre**, is a sore of special form and appearance, characteristic of the nature

* The student who wishes for further information on Venereal Diseases may refer to the 2nd edition of "Syphilis and Local Contagious Disorders," by Berkeley Hill and Arthur Cooper, in which will be found a complete summary of all that is known up to the present time.

of the disease. It may occur on the cutaneous, and the mucous, or muco-cutaneous surfaces, most commonly on the latter, on account partly of their greater exposure to contagion, but chiefly from their being less perfectly protected by epidermis. Chancres present much variety as to their appearance and to the course which they pursue : so great indeed are the varieties, that they have been looked upon by some Surgeons as affording evidence of distinct diseases proceeding from different poisons. This doctrine, however, is entirely erroneous ; the varieties in their appearance depend on seat, constitution, and other accidental circumstances. A chancre, then, is a specific venereal sore or ulcer, originating invariably from contagion, and capable of propagation to other parts of the same or different individuals by inoculation. Like all other ulcers, a chancre presents two distinct periods : the first, in which it is either spreading or stationary, in which alone it is specific, and which may be of almost infinite duration ; and the second, in which it has commenced to granulate, and a process of repair is set up in it.

Specific Nature.—Ricord and numerous other observers have shown clearly by experiment, that pus from a chancre, during its first period, if inoculated into any part of the surface of the body, will produce a specific sore of the same character. After the inoculation has been repeated a certain number of times the individual seems to become insusceptible to the poison, and no chancre follows the introduction of the pus. Boeck states that this occurs usually after three or four months of repeated inoculation, but the time varies with different individuals ; some never acquire an immunity, and in all it is only temporary. No pus that is not chancrous can occasion the specific venereal ulcer.

A simple chancre is a local infective inflammation, produced by the action of a virus which increases in quantity in the affected area. The increase of the poison is supposed to take place by a rocess analogous to fermentation occurring in the inflammatory exudations. Thus we see that the result of the inoculation of an infinitesimal dose of the poison may be the formation of a sore from which many drachms of infective pus may be discharged before the process ceases. The intensity of the local action of the poison is such as to cause a progressive destruction of the tissues by ulceration. As a rule it shows but little tendency to diffuse itself amongst the tissues, the area of inflammation beneath and around the ulcerating surface being usually very limited. Occasionally, however, from causes which are not fully understood, the intensity of the virus is greater ; it then extends more deeply, causing more rapid destruction, the dead tissues not being removed by ulceration, but remaining as an adherent pulpy slough. This form is described as the phagedænic or sloughing chancre. The virus of a simple chancre may be taken up by the lymphatics and carried to the nearest lymphatic glands, where it may set up an inflammation of the same character as that at the primary seat of disease. Beyond this it never goes, and although we must suppose that it is possible that it may enter the blood-stream, it certainly produces no general infection under any circumstances. Of the exact nature of the virus we know but little. Chancrous pus is said to lose its activity after drying, or after being kept for some time in capillary tubes. Its infectivity is readily destroyed by alcohol, corrosive sublimate, and many other chemical substances. No specific organism has as yet been shown to be constantly present in the discharges from a chancre.

Origin and Progress.—A chancre is necessarily contracted in most

cases during impure sexual intercourse with a person already contaminated by the disease. It usually commences with a small excoriation, which appears to have been directly inoculated with the specific poison. In other cases, though more rarely, it may be seen at first in the shape of a small pointed pustule, which speedily breaks, leaving an ulcer of a specific character in its site. Very generally, however, this pustule escapes observation, and the disease is presented in the first instance as an ulcer. The chancrous ulcer, whatever form it assumes, seldom makes its appearance until a few days (three to five), after connection. In some cases, however, I have observed it, evidently from the infection of a fissure or crack, on the day following impure intercourse; and occasionally, in rare instances, its appearance may be delayed a few days longer than that time which has been mentioned.

Berkeley Hill states that 99 per cent. of simple chancres are situated on the genital organs. They are occasionally met with, however, in irregular situations, as upon the fingers of Surgeons or Accoucheurs, from touching venereal sores, or attending diseased women during labour; but this is far less common with simple sores than with true syphilis. Simple chancres are also rare in the face compared to true syphilitic sores. The reason of this is that in the simple chancre the discharge from the sore is the only source of infection, while in syphilis, the secretions from the mouth, the discharges from secondary syphilitic sores, or even the blood, possess infective properties. In some cases, the disorder is contracted from the contact of filthy clothes or dirty utensils with the person; and not uncommonly, it is said, chancres are contracted at public water-closets. Although the latter mode of infection is not impossible, it should be received with doubt, as it is an explanation not uncommonly adopted by those who desire to account for consequences of an act of immorality, in a way that does not expose them to reproof.

In speaking of the mode of propagation of syphilis, Wiseman says: "It is frequent to mention other secondary ways of the propagation of it; as lying in the same bed with an infected person, lying in the same sheets after them, or wearing their cloaths. . . . . Drinking with one so diseased, or sitting on the close-stool after them, are likewise numbered among the causes of infection. These are all such convenient excuses for the more shie and coy patients, who will not otherwise be brought to confess their distempers, that it is pity to discountenance them" (Wiseman: "Several Chirurgical Treatises. Of Lues Venerea," London, 1676).

Whatever the appearances presented by a chancre, there can no longer be any doubt that the disease arises from one kind of virus only; the modifications in the sore depending on its situation, on the constitution of the patient, and occasionally on that of the individual who communicates the infection. That this is so, is evident from the facts that every chancre, when inoculated, reverts to one typical form; and that, however much chancres may ultimately differ, they all present the same characters during their early stages.

The progress of a chancre that has been artificially inoculated on any part of the cutaneous surface is as follows, and its study will serve to elucidate what takes place in other circumstances. During the first twenty-four hours after the introduction of the specific pus into the skin on the point of a lancet, we find that some inflammation is set up around the puncture, which becomes hot, red, and itchy. About the third or fourth day, a pointed pustule is produced, which is at first deep-set, but becomes on the following day more superficial

with some depression in the centre, resembling rather closely a smallpox pustule. On the fifth day the pustule bursts; and on the sixth it has usually dried, forming a small round scab, which comes off, leaving an ulcer which presents the typical characters of a true chancre, being circular and depressed, with an irregular "worm-eaten" surface of a foul greyish colour, which cannot be cleansed, sharp-cut edges, a base slightly indurated by inflammation, and an angry-looking red areola around it. Such induration as may be present is not sharply defined, but fades away into the surrounding healthy tissues. This is the typical chancre, and these are the appearances that every true venereal non-syphilitic sore on the skin will present about the fifth or sixth day after inoculation; from this time it may diverge more or less completely from these characters, but will yet, if inoculated at any time during the poisonous stage, produce an ulcer that will run the specific course up to the same period, after which it may in its turn again deviate into one or other of the unusual forms that chancres occasionally assume.

Varieties.—These have been described under various denominations by the numerous writers on these affections. The following classification will include them all:—1, the Simple or Soft Chancre, or Chancrous Excoriation; 2, the Sloughing Chancre; and 3, the Phagedænic Chancre. The particular form of the sore is in each case determined by its situation, and the constitution of the patient or that of the individual furnishing the contagion.

1. **Simple or Soft Chancre**, or **Chancrous Excoriation**, is certainly that form of the disease which is most commonly met with. It consists of one or more small sores, somewhat circular in shape, of a very shallow character, resembling rather an abrasion, with sharp-cut edges, sometimes slightly undermined, and having an irregular, spongy surface of a tawny greyish or yellowish colour, with a narrow red areola around the edge: in many cases attended with much heat and itching. These sores are usually seated on the cleft under the corona glandis, or about the glans, the whole of which may be studded by them. In fact, one peculiarity of this chancre is its tendency to multiplication on the contiguous structures. In other cases, the sores invade the frænum, which may be perforated; or they may occupy the mucous surface of the prepuce. In no case are they indurated.

The excoriated chancres not unfrequently present somewhat varying appearances. In some cases their surface becomes covered with large fungous granulations, hence termed *fungating sores*. In other instances they are very irritable, becoming exceedingly sensitive, with a tendency to spread, and having a dusky red areola around them. These chancres are very frequently attended by much general inflammation of the penis; the organ being red and swollen, from subcutaneous œdema, and usually in a state of phimosis, with much purulent discharge from between the prepuce and glans.

2. **Sloughing Chancre**.—This may be looked upon as a gangrenous inflammation of a non-infecting sore. It is usually the result of want of cleanliness, and of the confinement of the specific pus under a long foreskin. It is most likely to occur in weak and debilitated subjects, but it is also met with in healthy young men. The penis becomes red, greatly swollen, and somewhat brawny, the prepuce cannot be retracted, and foul, very offensive pus, often stained with blood, escapes from beneath it. If it be not relieved, a dusky black-looking spot soon makes its appearance on one side of the organ: this rapidly extends, thick black pultaceous sloughs form, and thus

one side of the foreskin may be destroyed, or a round aperture may form in it, through which the glans projects, whilst the swollen and inflamed extremity of the prepuce hangs down behind it, giving the organ a very remarkable, and, at first sight, somewhat puzzling appearance. As soon as the pent-up discharges find exit in this way, the intensity of the inflammation becomes somewhat relieved. In other cases the whole foreskin may slough, and the glans be deeply implicated, and even the corpora cavernosa denuded. Severe hæmorrhage from the dorsal artery or the artery of the frænum may take place. Not uncommonly the pus, being unable to find exit from the orifice of the swollen prepuce, bursts through the reflection of the foreskin at the corona, and burrows beneath the skin of the penis for some distance superficial to the corpora cavernosa. I have seen it extending in this way for a distance equal to the two first joints of the finger. In other cases, when the sore is near the frænum, it may perforate the urethra, leaving a fistulous opening which it may be impossible to close. After the separation of the sloughs, healthy granulations spring up, the sore loses its specific character, and cicatrization advances rapidly.

3. The **Phagedænic Chancre.**—This differs from the sloughing chancre in not being evidently due to want of cleanliness. It attacks sores that can be freely exposed, as well as those that are concealed beneath a long foreskin, and if occurring in the latter condition does not show the same tendency to cease extending as soon as the retention of the discharges and inflammatory tension are relieved by slitting up the foreskin. The sore may assume the phagedænic character from the very first, or this may be set up at some period of its course. Phagedæna affects both the simple chancre and the true syphilitic sore. In fact some Surgeons, especially Jonathan Hutchinson, believe that it is invariably syphilitic, either attacking a primary syphilitic sore or a soft sore in a person already suffering from syphilis, and Berkeley Hill states that a considerable proportion of cases are followed by secondary symptoms. As soon as the phagedænic ulceration sets in, the characteristic appearances of the sore are lost, so that it is not possible to say what form it had originally assumed.

The phagedænic chancre is characterized by a tendency to erosion, with extensive destruction of the parts that it invades. The progress of the sore varies greatly in its rapidity. In some cases it advances slowly and irregularly, healing at one part while spreading at another; thus forming the *serpiginous sore.* In other cases the advance is extremely rapid. In men the whole thickness of the penis may be destroyed for some distance, and in women the recto-vaginal septum may be perforated. Between these forms every variety may be met with. Wallace has divided phagedænic sores into three varieties: those *without slough*, those *with white slough*, and those *with black slough.* This classification appears to me to be a useful and practical one, and I accordingly adopt it.

The *phagedænic chancre without slough* is a truly eroding ulcer, spreading with sharply-cut edges, attended by slight inflammation, and with moderate activity of progress; it is commonly observed about the frænum and under part of the glans, and very frequently hollows out and destroys the organ in this situation to a considerable extent. When reaching the skin, it often assumes the serpiginous form.

In the *phagedænic chancre with white slough*, we find an irregular eroding

ulcer, with a thin margin of white slough situated at the junction of the dead and living structures; that which covers the surface of the sore having usually become darkened by exposure to air, to dressings, and to secretions.

The *phagedænic chancre with black slough* differs but little from the last, except in the colour of the slough, which may be in a great measure accidental, and in its tendency to somewhat rapid extension.

Phagedænic sores are most commonly met with in persons suffering from debility from want of food, or after exhausting diseases, and in scrofulous subjects. Chancres are also very apt to assume this form amongst troops exhausted by the hardships of a campaign. Phagedænic sores when spreading rapidly are often accompanied by much pain and a good deal of constitutional disturbance.

Situation.—As simple chancres almost invariably result from connection with persons suffering from sores of similar nature, they commonly occur on the genital organs. In the **male** they may be met with in any part of these; their characters vary somewhat, however, according to the situation in which they occur. They are by far most commonly seated in the angle formed between the glans and the prepuce; the situation next in order of frequency is the orifice or the inner surface of the prepuce, next the frænum, then the glans, more rarely the orifice of the urethra, in some cases extending a short way down the canal, and lastly the skin of the body of the penis. Those about the frænum are often sloughy and irritable, have a great tendency to perforate or destroy this membrane, and are more frequently followed by hæmorrhage or bubo than any of the other varieties of the disease.

Chancres may also form on other parts where they have been accidentally or purposely inoculated. Thus I saw many years ago (1839) in Ricord's wards, a man, labouring under *eczema of the legs*, in whom the cutaneous disease had been converted into a series of immense chancres by accidental inoculation from a sore on the penis.

In **women**, chancres are most commonly situated on the external organs of generation, usually just inside the fourchette or labia minora, very rarely indeed on the lining membrane of the vagina, but sometimes on the cervix or os uteri; hence it is impossible ever to pronounce a woman free from chancre without examining these parts by means of the speculum. When situated upon the external organs, they are not unfrequently concealed between the rugæ, or in nooks and corners of the mucous membrane. In these cases, their presence may sometimes be detected by the labia being swollen and œdematous from the irritation produced by them.

Diagnosis.—The diagnosis of chancre is usually not difficult, the peculiar character of the sore enabling the Surgeon to recognize it in all its forms. In some instances, however, it is by no means easy to say positively whether an ulcer on the penis be or be not chancrous. It is especially difficult to distinguish some forms of excoriated chancre from herpes on the prepuce or glans, or from those slight excoriations that many men habitually contract after a somewhat impure connection; so, also, the wound resulting from a ruptured frænum often presents a suspicious appearance.

Herpes of the prepuce is recognized by the closely-set crop of small vesicles with some redness round them. Herpes may become inoculated with the poison of a chancre. Pustules then quickly form in the place of the vesicles,

and burst, leaving a number of small sores which soon coalesce. A simple excoriation, or the wound from a ruptured frænum, can only be distinguished from a chancre by watching the sore for a few days; but it is better not to wait till the characteristic appearances show themselves, but to treat every doubtful case as a soft chancre. When the prepuce is in a state of inflammatory phimosis, it is always extremely difficult to determine without slitting up the prepuce whether there be chancres under it, or whether the discharge be due to simple balanitis or gonorrhœa. Sometimes, however, the inflammatory induration round the sores can be felt through the swollen foreskin.

The diagnosis of the simple non-infecting chancre from the primary syphilitic sore will be described with the latter affection. It is for this purpose only that the inoculation of the discharge or the administration of mercury could be suggested as a means of diagnosis.

Treatment of Non-infecting or Soft Chancres.—The treatment of venereal sores has engaged the anxious attention of the most eminent Surgeons; and until the simple non-infecting chancre was clearly distinguished from the true syphilitic sore much difference of opinion and practice prevailed. It is now, however, fully recognised that the simple chancre, being a local disease, and occurring in the great majority of cases in persons otherwise in perfect health, requires no constitutional treatment beyond a general attention to the patient's health. The gangrenous and phagedænic forms, on the other hand, being often accompanied by serious constitutional disturbance, or depending partly on a debilitated state of health, require constitutional treatment as well as local.

Local Treatment.—This has for its object either the destruction or the modification of the specific character of the sore.

With a view of modifying the specific character of the sore, there is no application so efficacious as *iodoform*. It will usually cure a simple soft chancre in a week or ten days. The crystalline, and not the precipitated iodoform should be used, as the latter sometimes causes irritation. It is applied by simply dusting a small quantity of the powder on the sore twice a day, and afterwards covering it with a small piece of cotton wool, either simple or impregnated with iodoform. At each dressing the sore must be carefully washed with tepid water. The only objection to this treatment is the powerful smell of the drug. If the pure iodoform is used, it is better to apply it before dressing in the morning and after undressing at night, to avoid any chance of its falling upon the clothes. Berkeley Hill recommends the use of "iodo-carbon paste," composed of iodoform in fine powder, ʒj; wood charcoal, ʒij; glycerine of starch, ʒij; glycerine, ʒj; oil of lavender, ♏xx; or a solution of iodoform in eucalyptus oil: iodoform, ʒiss: oil of eucalyptus, ℥j; olive oil, ℥v. By both these preparations the smell is very efficiently concealed, but if the odour is not a very great objection, there is nothing so efficient as the pure crystals.

Should the iodoform not be at hand, or the objection to its use be very great, the specific sore may be destroyed by caustics. The complete destruction of the local virus should always, if possible, be effected; and if this can be done in the early stage of the disease, the healing of the sore will be much expedited. But, even though considerable time have passed before the Surgeon sees the sore, it is well to destroy the ulcerating and poisonous surface, that its further extension may be prevented. This should be effected by the appli-

cation of caustics in a sufficiently concentrated form to destroy radically and at once the specific character of the sore, so as not only to save the pain, but to prevent the irritation attendant upon frequent applications. The nitrate of silver, which is often used for this purpose, is too weak to secure the effect it is intended to accomplish, being apt to irritate, and not to destroy the chancrous surface, thus necessitating repeated and painful applications. I consequently prefer to this the strong nitric acid, one application of which will very commonly suffice to annihilate the specific character of the sore: though more energetic in action, it does not give rise to more pain than the nitrate of silver. It should be applied by means of a piece of wool, or a glass rod; with this the sore may be freely rubbed, and then, a stream of cold water having been poured over it to wash away any superfluous acid, a wet dressing should be laid on; after the small slough produced by the caustic has separated, a healthy granulating surface will be left. The caustic may be applied at any time during the continuance of the specific condition of the sore; but when once this has been destroyed, it should not be re-applied. The patient should be kept as much at rest as possible if the sore be of any size, and he should when moving about have the penis supported against the lower part of the abdomen by means of a handkerchief.

After a chancre has been cauterized, as soon as the slough separates, the surface may begin to granulate healthily at once, requiring but simple dressings; but in many cases it will continue in a somewhat unhealthy condition, demanding special topical applications to cause it to cicatrize soundly. If it be weak and fungating, an astringent lotion, such as the following, will be found most useful. ℞ Tannin, gra. xx; Tinct. lavandulæ comp. ʒij; Vini rubri, ℥iv. Ft. lotio. Or a solution of sulphate of copper may be applied, and the sore touched from time to time with nitrate of silver.

In using lotions to any form of chancre, care should always be taken to keep a piece of lint soaked in the fluid constantly applied between the prepuce and the glans, and, in women, between the opposite labia; for, unless this be done, the contact of the diseased and inflamed mucous surfaces with one another will tend to keep up the irritation and ulceration.

These are the means that are generally most useful in *Simple Chancres*. In some cases, however, inflammation of the sore, or peculiarities in its situation, demand modifications of the treatment.

If there be much inflammation about the sore and prepuce, this must first be subdued by the application of wet dressing, or of lead and spirit lotion. When this is removed, if the sore have not lost its specific character, the caustic should be applied in the usual way.

Should there be phimosis with discharge of pus from under the tightened prepuce, this must be slit up, so as to expose the subjacent chancres. It is better at the same time to complete the operation of circumcision by removing the foreskin with the knife or scissors after it has been slit up along its dorsal aspect. Otherwise when it heals an inconvenient pendulous flap of skin will be left, requiring subsequent removal. In order to avoid infection of the raw surface from the chancre, the operation should be thus performed. The foreskin is first slit up and the chancres exposed; the surface of the glans and the prepuce are then thoroughly cleaned with carbolic lotion (1 in 20), and the sores wiped out with chloride of zinc solution (40 grs. to ℥j). The surface of the sore may be rubbed forcibly with a dossil of lint soaked in this solution,

to remove any adherent slough. Everything being thus thoroughly cleaned the operation of circumcision may be completed; after ligaturing any bleeding vessels, the parts must be thoroughly sprinkled with iodoform and wrapped in iodoform wool. By these means infection of the wound can generally be avoided. There should be no delay in performing the operation. When pus comes from under a long foreskin and its source cannot be seen, the patient should always be advised to submit to circumcision, unless there is some very marked improvement, following the application of fomentations and the injection of antiseptic solutions, by the third day at latest. If the pus is offensive the operation should be performed at once, as it probably arises from a sloughing chancre.

If the chancres be situated round the orifice of an elongated and tight prepuce, circumcision is the best means of removing the disease and the inconvenience at the same time. The precautions just described must be adopted to prevent infection of the cut surface.

In the **Sloughing Chancre,** when the prepuce is greatly tumefied, in a state of inflammatory phimosis, and of a deep red or purplish colour, with threatening of extensive gangrene, a director should be passed between it and the glans penis, and the swollen prepuce slit up. In this way tension is removed, and the sloughing arrested. The chancre when exposed will be found to be covered with a pulpy grey tenacious slough. This is best removed by forcibly rubbing the surface with a piece of sponge or lint soaked in a solution of chloride of zinc (gr. 40 to ℥j), after which iodoform must be applied. The application of nitric acid is seldom necessary. If the state of the parts is such as to admit of it, the operation of circumcision may be at once completed. If there be much sloughing of the prepuce it is better to delay the completion of the operation till the sloughs have separated, when perhaps it may be found unnecessary. During the separation of the sloughs the penis should be wrapped in lint soaked in some warm antiseptic solution, as boracic acid or permanganate of potash. The patient should sit in a hot hip-bath, to which some solution of permanganate of potash (Condy's fluid) may be added, for half an hour or more twice a day. A little hæmorrhage need cause no anxiety, and is usually early arrested by dry cotton wool and pressure, but if it occur to an alarming extent, the patient should be put under chloroform, and the actual cautery freely applied. This not only stops the bleeding, but arrests the progress of the sloughing. When once the chancre is healthily granulating, it must be dressed in the same way as any common ulcer.

The local treatment of the **Phagedænic Chancre** depends on the form it assumes. If it be the eroding ulcer without slough, iodoform will often arrest it, but its action is by no means certain. If it fails bichloride of mercury (gr. ij to ℥j), diluted if it is too painful, is often of great service. Should this fail the strong nitric acid may be applied, after which it may be dressed with a dilute nitric acid and opium lotion. If the phagedænic process be spreading rapidly with a white or black slough, the sore must be treated like hospital gangrene. The slough must be scraped away, and fuming nitric acid, or in bad cases the actual cautery, applied freely, after which iodoform and boracic acid fomentations, or lint soaked in the nitric acid and opium lotion may be used, the caustic being applied again whenever there is any tendency to extension of the disease. In obstinate cases of phagedænic chancre Hebra in Germany and Hutchinson in this country have recommended that the patient

should be immersed for ten hours daily in a bath of hot water, maintained constantly at a temperature of 98° F. The bath must be repeated daily till healing is distinctly taking place.

Constitutional Treatment.—The **Simple, Soft,** or **Excoriated** sore requires no constitutional treatment beyond attention to the ordinary rules of health.

In the **Sloughing Chancre** it frequently happens that the mischief is entirely due to local causes, such as the accumulation of discharge under a long foreskin. In these cases the constitutional disturbance, which may be severe, will subside as soon as the local condition is relieved. In other cases the sloughing is due partly to local causes and partly to a depressed state of health. In these ammonia and bark, good nourishment and abundant stimulants will be required. Opium may be necessary to relieve pain and irritability, and eventually the patient's strength may be supported by iron and quinine. In a sloughing chancre mercury is never required.

In the constitutional treatment of **Phagedænic Chancre** it must be borne in mind that the patient is usually in a debilitated condition before the invasion of the disease ; consequently tonics, such as bark or iron, with good food and stimulants, are frequently required, together with opiates to allay pain and procure rest. The preparations of iron, especially the ammonio-citrate and the tartrate, either alone or in combination with sarsaparilla, are especially useful in these cases. It has before been stated that phagedænic ulceration may start from a true syphilitic sore or occur in a patient suffering from constitutional syphilis. Mercury is, however, often inadmissible, and if given indiscriminately may do much harm in many cases by further debilitating the patient. On the other hand some sores which have resisted treatment for a long time may rapidly improve if mercury be carefully administered in small doses. Wallace stated that its beneficial effects were most marked in those cases which are characterized by the presence of a white slough. It is best given as the perchloride, in doses of $\frac{1}{32}$ to $\frac{1}{16}$ of a grain with tincture and decoction of cinchona. It is in these cases also that the local application of perchloride, in the strength of from one to two grains to the ounce of water, is so frequently useful.

CONSECUTIVE SYMPTOMS OF THE LOCAL CONTAGIOUS ULCER.—Chancres are not unfrequently followed by a series of affections which may be termed *consecutive*, depending as they do upon the primary disease, but being local in their character, and presenting no evidence of constitutional infection. These consecutive symptoms are three in number : viz., Contraction of the Cicatrix of the Chancre, Bubo, and Warts.

Contracted Cicatrices.—Most excoriated chancres are healed without any marked cicatrix being left ; but, in the phagedænic and the sloughing chancres, there is always loss of substance, often to a considerable extent, and consequently a depressed scar. If the ulceration happens to have involved the orifice of the urethra a very intractable stricture may result, which may subsequently necessitate division of the scar for its relief. The situations of all venereal ulcers should be watched for some time, however readily the sore may have healed ; for the virus of syphilis may have been introduced with that of the simple chancre, and if this have happened induration will commence at the point of contagion, when the time of incubation or inactivity of the virus has elapsed. Thus a month or six weeks should pass away after the suspicious connection, before the Surgeon pronounces the patient safe from syphilis.

Bubo.—By bubo is meant an inflammatory enlargement, frequently terminating in suppuration of the lymphatic glands which receive the lymph-stream from the inoculated surface. A bubo, though generally produced in the groin by absorption of irritating matter from chancres on the penis, may occur elsewhere; as for instance, in the axilla, in cases of chancre on the finger; in the submaxillary region, if the disease occur on the lip. The enlargements of the inguinal or other lymphatic glands that occur in cases of venereal chancre, may be either simple or specific. In the former the irritating material may be derived from concomitant inflammation about the sore, as when balanitis or phimosis is present, without the specific virus of the soft chancre reaching the gland. In scrofulous subjects this readily takes place. In these cases the bubo is termed *sympathetic*, and the affection must be considered as simple inflammation. It may speedily subside without the formation of pus, but should suppuration take place the pus possesses no specific properties, and is not inoculable. It constitutes in fact a simple glandular abscess and presents nothing in any way peculiar. Indeed, in a very large proportion of cases of simple chancre there is some slight enlargement and tenderness of the glands above Poupart's ligament, accompanied by some degree of stiffness and dragging pain. The liability to irritation and inflammation of the glands in the groin is greatly increased by the patient walking about or otherwise exerting himself. But I do not think that causes such as these influence the occurrence of the other and more troublesome affection of the lymphatic glands, namely the *virulent bubo*, which appears to originate from direct absorption of the specific poison of the chancre; so that we may consider with Ricord that a virulent bubo is, properly speaking, a chancre of a lymphatic gland, differing only in seat from that which is situated on the surface of the body. Ricord has observed, and I have often had an opportunity of testing the correctness of this observation, that the pus of a virulent bubo is as readily inoculable as that of an ordinary chancre. This kind of bubo, then, may be considered as a *specific* abscess, at first limited to the gland, but subsequently infecting the surrounding tissues. Ricord also pointed out that in some cases suppuration takes place round the affected gland without infection of the tissues with the specific pus. Thus if a virulent bubo be carefully opened a cavity is sometimes exposed in which the gland can be seen partially separated by pus from the surrounding tissues. Inoculations made with the pus surrounding the gland may fail, but if the incision be carried further into the gland itself a second cavity is found containing inoculable pus. If this condition be met with, infection may be prevented by scooping the gland out entire without opening into it. When once a gland has become virulently infected, it is probable that no treatment can prevent suppuration.

Usually only one or two glands suppurate, although several may be enlarged; and very commonly the disease is confined to one groin only, though both may be affected, more particularly if the chancre be situated on the frænum.

In the early stages it is impossible to distinguish a sympathetic from a virulent bubo. The glands become swollen and tender; at first they are not adherent to the skin, and their form and outline can be clearly recognized. As soon as the inflammation extends to the tissue outside the capsule, the glands become lost in the surrounding inflammatory exudation. The swelling is at first brawny and hard, but it soon becomes softer and boggy, after which

distinct fluctuation becomes perceptible. The skin, at first red, becomes dusky and purple, and if the case be left to nature, it is frequently extensively undermined before the bubo bursts. If the bubo be simple, the cavity presents nothing differing from that of an ordinary abscess. If it be virulent its walls are ragged, sloughy-looking and unhealthy, and instead of healing the sore may spread, with all the characteristics of a chancre.

Bubo most commonly occurs during the second or third week after the first appearance of the chancre, but may happen at an earlier or at a later period, even after the chancre itself has healed.

A rare form of bubo is that which forms within the abdomen in the lymphatic glands in this situation. It is a very dangerous variety, and may prove fatal by rupture into the peritoneum and consequent peritonitis.

Primary Bubo.—The French Surgeons have described a form of bubo that they call *bubon d'emblée* or *primary bubo;* this is said to occur from the direct absorption of the specific poison, without the previous formation of a chancre. Only one case apparently of this kind has fallen under my observation. Until that occurred, I doubted its existence; and I am not yet fully convinced that this suggested mode of origin is the true one. In the case referred to, a young man applied to me with a rather large abscess in the groin, for which I sent him into the Hospital. On being questioned, he denied ever having had any venereal disease, though he admitted having had intercourse with a woman of the town. On examining the penis, no chancre, abrasion, or cicatrix could be discerned. The abscess was opened, and two ounces of rather bloody and very thick pus were let out; no enlarged glands could be seen. For the sake of experiment the pus was inoculated into the left thigh, and two distinct and well-marked pustules were produced. That such an effect can be obtained by matter of very irritating character without any venereal origin, is shown by the experiments of several Surgeons who have succeeded in inoculating matter from itch and ecthymatous pustules; hence it must not be concluded in this case that the bubo was consequent on the direct absorption of venereal matter along the lymphatics. In fact, the proof of the existence of this form of bubo is far from satisfactory. It frequently happens that small excoriated chancres heal in a few days, before which time, however, the inguinal glands have become irritated and enlarged; and, as the enlargement of the glands goes on after the healing of the chancre, a bubo may be formed when all trace of its primary source has entirely disappeared.

Creeping Bubo.—In some cases a virulent bubo, as has been well shown by Solly, assumes a tendency to creep or spread over the neighbouring integument, extending in this way to a considerable distance down the thigh, upon the abdomen, or over the ilium. This *creeping bubo* is characterized by the peculiar semicircular or horse-shoe shape that the sore assumes, and by its tendency to cicatrize by one margin, whilst it slowly extends by the other; the cicatrix always being thin, blue, and weak, closely resembling that of a burn.

After a bubo has disappeared, a good deal of induration may be left in the glands of the groin, perhaps with matting together of the surrounding areolar tissue; and this induration may continue for years, or even for the remainder of life.

The *Treatment* of bubo consists, in the first instance, in endeavouring to prevent the occurrence of suppuration; and should pus form, in letting it out.

The *Preventive Treatment* of bubo is of considerable moment. It consists essentially in perfect rest of the part, and the application of leeches and of cold lead lotions. In reference to the application of leeches, there is a practical point of considerable importance that requires attention—viz., that the leech-bites may become infected by the chancrous pus, and thus converted into a number of new chancres. This accident is best guarded against by covering the bites with collodion and plaster.

If there be much pain, and if the skin be already reddened, hot fomentations, and the application of an ointment composed of equal parts of Extract of Belladonna and Glycerine, will offer the best chance of arresting the progress of the inflammation.

If the bubo be indolent, with but little tendency to suppuration, the application of blisters or tincture of Iodine may be of service. B. Hill states that steady pressure by means of a pad of cotton-wool and an elastic bandage may sometimes produce absorption. The application of lint soaked in a lead lotion containing about two drachms of the solution of the subacetate and one ounce of spirit to half a pint of water has been said to favour resolution.

If notwithstanding our endeavours to prevent suppuration, matter form within or around the gland, as evinced by the swelling becoming soft, boggy, and inflamed, a free opening should be made. This should, as a rule, be parallel to Poupart's ligament, but if a vertical incision would lay the cavity open more perfectly, there is no objection to adopting it. The incision should be made early, before the surrounding skin has been undermined and thinned. If this should have happened it may be necessary to destroy the thinned skin with potassa fusa, or to cut it away with scissors, before healing will take place.

After the bubo has been opened it should be dressed from the bottom, either with salicylic or iodoform-wool or lint soaked in carbolic oil (1 in 10), or terebene and oil or some such simple application.

If the cavity presents a chancrous appearance, being irregular and sloughy, with elevated and angry red edges, it should be treated by the free application of iodoform in the same way as for the original sore. If on opening the bubo a gland can be seen projecting into the cavity, attached only by one side to the wall of the abscess, this is best scooped out either with the thumb-nail or the handle of the scalpel, otherwise it is apt to keep up the suppuration and delay healing.

Sometimes, even after the bubo has been opened, the pus may burrow in various directions. Such cases are best treated by laying open the sinuses freely to the very end with a probe-pointed bistoury.

Zeissl recommends opening the bubo by means of a number of small punctures made with a tenotomy knife, after which lint soaked in lead lotion (Liquor Plumb. Subacetatis, ʒ ss., Rectified Spirit, ʒ j, water, to O j), may be kept constantly applied. By this means, he says, that scarring can often be avoided.

Should sloughing or phagedænic ulceration commence in an open bubo, extensive destruction of tissue may ensue, and even fatal hæmorrhage from the femoral artery has been known to occur. The sore must be treated in the same way as the sloughing or phagedænic chancre.

The application of nitric acid is occasionally necessary. If there be any signs of syphilis the cautious administration of mercury may be required.

During the treatment of a suppurating bubo the patient should, if possible, be kept at rest till the sore is superficial; movement greatly delays healing.

Venereal Warts.—Warts occur frequently round or on the scar of a chancre, independently of any constitutional affection, but merely from simple continued irritation of the muco-cutaneous surfaces. They differ in no respect from those which frequently follow gonorrhœa. They commonly occur on the prepuce or glans, and are especially apt to be situated in the angle between these parts; they are of a red colour, very vascular, and, if left without interference, may increase immensely in size and number, distending the prepuce, and giving a clubbed appearance to the penis; there is then always phimosis, and the tension of the prepuce may be such, that ulceration occasionally takes place in it, allowing a protrusion of these growths through an aperture in its side. These warts are occasionally met with on the labia, forming large, irregular, cauliflower-looking masses. The *Treatment* consists, first in laying open the prepuce unless the warts are so small that the glans can be readily exposed by drawing the foreskin back. The warts may then be pared off with scissors, and the part from which they grow touched with nitrate of silver. Even after this they are very apt to recur, especially under a long, moist foreskin. In such a case careful attention to cleanliness and the application of an ointment composed of vaseline, with about one tenth part of extract of belladonna added to it, will usually cure the tendency to recurrence. In women, warts must be treated in the same way: but if they are of great size, Paquelin's cautery should be used in removing them to avoid loss of blood.

II.—SYPHILIS.

Syphilis is a specific disease, or general infective process, resulting from the inoculation of a specific virus, which multiplies in the system till the whole body is infected. It is communicated by the direct contact of the blood, secretions, or discharges of a person suffering from syphilis with an abraded surface of a healthy individual, and under certain circumstances it is also transmitted from syphilitic parents to their offspring. It is therefore contagious, but not infectious.

The exact nature of the virus is not known. Klebs, Birch-Hirschfeld, and some others, have described a special microscopic organism of an oval form, or nearly approaching a short rod in shape, which they believe to be in some way connected with syphilis. Birch-Hirschfeld observed it in gummata, and in a flat condyloma, but failed to detect it in the blood of a patient suffering from active syphilis. More evidence is required before any conclusions for or against the fungoid origin of syphilis can be drawn from these observations.

Syphilis is divided into *acquired* and *hereditary or congenital*, and there is sufficient difference between these two forms to justify their being described separately.

Syphilis runs a course tolerably definite in its main phenomena, but varying in duration and detail. It is divided into various stages, which, although perhaps not capable in all cases of being sharply separated from each other, are sufficiently distinct to be used as a means of classifying the manifestations of the disease.

The *first* stage is the **period of incubation**, extending from the inoculation to the appearance of the local signs of the disease at the seat of infection.

The *second*, or **Primary Stage**, includes the appearance of the characteristic initial manifestation, the indurated sore, accompanied by indolent enlargement of the nearest group of lymphatic glands.

The *third* includes the period during which the so-called **Secondary Symptoms** make their appearance. These consist of more or less symmetrical eruptions on the skin and mucous membranes, ulceration of the tonsils, condylomata, periostitis, iritis, loss of hair, &c.

The *fourth* stage, or **Tertiary Syphilis**, includes the more remote effects of the disease, such as the formation of gummata, deep unsymmetrical ulceration of the skin or mucous membranes, and various deep-seated visceral affections. Only a comparatively small proportion of those infected suffer from tertiary symptoms.

Between the secondary and tertiary stages an interval of perfect health may intervene, perhaps interrupted by occasional relapses of the secondary symptoms. During the intervals of health, the syphilis is said to be "*latent*."

The **duration of these various stages** is uncertain. According to Berkeley Hill, the period of incubation in thirty-seven trustworthy cases of experimental inoculation collected from various sources, varied from ten to forty-six days, the average being twenty-four. The most common periods were twenty-five and twenty-eight days. The duration of the primary symptoms depends very much on treatment, but it seldom extends beyond a month or six weeks. The secondary symptoms commence from two to three months after inoculation, and last from a few weeks to a year. The period of development, and the duration of the tertiary symptoms, are too indefinite to be stated with any approach to accuracy. Symptoms classed as tertiary may appear immediately after the secondary signs, or may prove fatal after many years of apparent health.

One attack of syphilis confers upon the patient, as a rule, an **immunity** for the future from the primary or secondary forms of the disease. Second attacks are, however, not unknown, but they are not more frequent than in small-pox or measles. When the patient has the misfortune to suffer a second time, the symptoms are never so severe as in the first attack.

From a consideration of the course of the disease as above described, with its periods of incubation, and of invasion, its sequelæ, and the immunity it confers from a second attack, Jonathan Hutchinson long ago pointed out its analogy to the specific fevers. He regarded the disease as a specific fever of a very chronic nature and irregular course. As at the present time the acute specific diseases and syphilis are equally included in the group of general infective processes, Hutchinson's views may be said to be generally accepted.

Origin of Syphilis.—It would be altogether foreign to the scope of this work were I to enter into the very curious and interesting question as to the *origin of syphilis*, a subject that admits of much dispute, and which has been keenly argued. After an attentive examination of it, I think there can be little doubt that syphilis was either introduced into Europe, or originated there *de novo*, towards the end of the fifteenth century. There is no mention made by the medical writers, historians, or poets of antiquity of any contagious disease arising from sexual intercourse affecting the genital organs, and followed by constitutional symptoms. The disease, when it first attracted public attention, at the close of the fifteenth century, was looked upon as a previously unknown affection. It was supposed to be infectious as well as

contagious, and its treatment was not understood. This would scarcely have been the case had it been previously known by personal observation, or even by tradition, to those then living. If it had previously existed in the old world in a mild or modified form, different from what we now observe, it is certain that about this time it suddenly assumed greater intensity, all its symptoms being aggravated in a remarkable and fearful manner, presenting characters which had not been previously alluded to, but which have often been reproduced in modern times; as, for instance, in those severe forms that were observed in the British armies during the Peninsular war, and, according to Larrey, among the French troops during Napoleon's German campaigns.

Contagion of Syphilis.—Syphilis is communicable, 1st, by the direct inoculation of any fluid containing the specific virus; and 2nd, from parents to their offspring.

1. **Direct Inoculation.**—In discussing this question, it is necessary to consider first what fluids or secretions of a syphilitic subject contain the virus, and secondly, the various ways in which the virus may be communicated from one individual to another.

That the discharge from the primary sore, whether it be thick and purulent or simply serous, is inoculable, is too well known to require further notice.

The contagiousness of the discharges from secondary syphilitic sores has also been demonstrated by numerous experiments. The thin secretion from mucous tubercles of the vagina, anus, and mouth, has frequently been shown to be capable of causing infection. The blood itself, in more than one instance, has been inoculated with success. Professor Pellizzari, of Florence, inoculated a young Surgeon, Dr. Bargioni, on the 6th of February, 1860, with blood taken from the vein of a woman suffering from syphilitic eruptions. The site of the inoculation, which was carefully protected by a watch-glass cover, remained quiet for twenty-five days; then a papule developed, which in forty-four days became an ulcer with hard base. On the sixty-fifth day after inoculation, a roseola broke out on the trunk.

Some uncertainty still exists as to whether the natural secretions of syphilitic persons are contagious of themselves, or become so by admixture with the blood or the discharge of syphilitic affections. The saliva, the milk, and the semen have been inoculated on healthy individuals with almost invariably negative results. So far, therefore, it may be said to be proved beyond a doubt that the discharges from all secondary syphilitic infections, and the blood of patients suffering from acute syphilis, contain the specific virus, but there is no definite evidence to show that the secretions of apparently healthy mucous surfaces or glands in a syphilitic subject are capable of transmitting the disease.

The actual inoculation of the virus may take place in many ways. There is no reason to believe that it can enter the system through an unbroken epithelial surface. On the other hand, it readily infects any surface from which the epithelium has been removed, by abrasion, vesication, or ulceration. Wounds or punctures are also readily inoculated.

Infection naturally takes place in most cases during coitus, and the primary manifestation is usually situated in those parts most likely to suffer from abrasion during the act. Whether the vaginal mucus of a syphilitic woman is capable of conveying the poison, if she be not at the same time suffering from primary sores or mucous tubercles, is uncertain.

The next most common source of infection is the secretion of the mouth. As before stated, the saliva alone has not been proved to be capable of conveying the poison, but if mingled with the secretion from mucous tubercles or the discharges from secondary ulcerations of the tongue or tonsils, it is undoubtedly infectious. The disease is then most commonly communicated by kissing, and the primary sore appears on the lip or cheek. Authentic cases are also on record in which the infection has been carried by drinking vessels, spoons, or pipes, and in one case the primary sore appeared on the knuckle in a cut received whilst striking the affected person in the mouth. Infants suffering from inherited syphilis have infected their wet-nurses, the primary manifestation appearing at the nipple. This point is one of very great importance, inasmuch as actions for damages have been brought by women who have stated that they have become diseased from the child that they have nursed. There are so many cases of the kind recorded, that there can be no doubt as to the possibility of the occurrence. Hunter and Lawrence related cases in which an infected child communicated the disease to several nurses in succession; in Hunter's cases three wet-nurses were successively infected, two of whom gave the disease again to their own children. A considerable mass of evidence upon this point is to be found in *Ranking's Abstract*, vol. iv. The disease is especially apt to be communicated in this way, if the nurse have any crack or abrasion upon her nipple, and the infant sores on the mouth. Colles, however, who had great experience in syphilis, states that the disease may be communicated to the nurse from an infected child by mere contact, without excoriation; but when we consider that a period of three weeks or more may intervene between inoculation and the appearance of any sign of the disease, the statement must be accepted with considerable caution.

Whether a wet-nurse can infect the child she suckles through the medium of the milk is a more doubtful question, and cannot be said to be finally determined. Ricord and many others of equal authority believe it to be possible, and my own opinion is that syphilis has been transmitted in this way, though very rarely. In *Ranking's Abstract*, vol. iv., a number of cases are recorded in proof of its occurrence.

Primary sores on the finger are unfortunately by no means uncommon amongst Surgeons and accoucheurs, who become infected whilst dressing syphilitic sores or attending diseased women in labour. Washerwomen are said to have been infected in the hands by washing linen soiled by the discharges from venereal sores.

The transmission of the disease by *vaccination* with lymph taken from a child suffering from congenital syphilis was until comparatively recently denied by most authorities. It has now, however, been placed beyond a doubt that the disease can be thus communicated. One of the most unquestionable of these accidents is that which occurred in the Sub-Apennine valley of Rivalta in Piedmont, in 1861. Dr. Pacchiotti, of Turin, who was employed by the Italian government to report on the attack, has published an account of it. The facts are shortly these. In May, 1861, an apparently healthy child, named Chiabrera, was vaccinated at Rivalta with lymph sent from Acqui for the purpose. Ten days after this vaccination—on June 7th—forty-six healthy children were vaccinated at one sitting from this child. Again, on the 12th June, seventeen other healthy children were vaccinated from one of the forty-six. Thirty-nine of the first series of forty-six, and seven of the second series

of seventeen, received syphilis with the vaccine disease, making a total of forty-six out of sixty-three children simultaneously inoculated with syphilis in a mountain village. Some months elapsed before the vaccination was suspected to have been the source of the children's bad health. By the 7th October, when attention was drawn to this spreading disease, six of the forty-six syphilized children had died without receiving any treatment, fourteen were recovering, and three were in a precarious condition. Twenty-three were dispersed through the country, and their condition was unknown until further researches traced them out. In addition to the children, twenty women suckling them were inoculated with syphilis from the children; through the mothers, the disease had reached some of the husbands and even the elder children of the different families. The history of this outbreak of vaccino-syphilis shows that the disease appears in only a certain proportion of those inoculated with the lymph. It has been attempted to explain this by supposing that syphilis is only spread when blood is mixed with the lymph, and that pure lymph will not spread syphilis even when taken from a syphilitic child. The evidence, however, at the present time is not sufficient to prove this definitely, but it is enough to impress upon every vaccinator the necessity of not only carefully examining every vaccinifer for syphilis, but also of obtaining the lymph free from contamination with blood, even when taken from an apparently healthy child.

Syphilis has been transmitted in one well authenticated case (see p. 262) by *skin grafting*. In this operation the grafts are cut of sufficient thickness just to draw blood, so that there is no difficulty in understanding how the poison may be conveyed from one person to another.

2. **Transmission of Syphilis from Parent to Offspring.**—The mode of communication of syphilis to the ovum, or to the fœtus in utero, is an investigation that has much occupied the attention of Surgeons, and is of considerable practical interest. It has been considered probable, that the poison may be communicated to the embryo in at least four ways; *viz.*, 1, the father may have a constitutional taint of which he has been imperfectly cured, and, without communicating any syphilitic disease to his wife, may be the parent of an offspring that exhibits indications of being infected; or, 2, the mother, having a similar constitutional disease, may in like manner taint her own offspring; or, 3, the diseased child may be born of parents, both of whom are constitutionally infected; or, 4, the mother may become pregnant with a healthy embryo, but, afterwards, contracting syphilis, may transmit it to her offspring.

There are very good reasons for believing that the disease does not pass from the father to the child without also implicating the mother. In the first place, this faculty is shared by no other contagious disease. No father can give his offspring small-pox, though the mother frequently communicates that disease to her fœtus. In the next place, it is well known, as Colles of Dublin long ago pointed out, that a congenitally syphilitic child never locally infects its mother, though it will transmit its disease readily to a wet-nurse, whose breast it sucks; this apparent exemption of the mother being due to the fact that she has been already infected. Again, the symptoms of syphilis are often exceedingly mild in women, and constantly overlooked. Hence, in the present state of our knowledge, it is safer to conclude that the father infects the mother, and that she transmits her disease to the offspring.

Ricord, however states that a mother, pregnant with a syphilitic fœtus, the offspring of a father labouring under constitutional disease, can be infected through it without herself having had primary syphilis; and Jonathan Hutchinson has advanced a considerable amount of evidence in support of this doctrine, which, nevertheless, fails to carry conviction to my mind that such communication ever takes place.

Duration of Transmissive Power in the Parents.—This question is one of great importance as bearing on the question of marriage of persons who have suffered from syphilis. There can be no doubt that the power to transmit the disease lasts during the whole time that the secondary manifestations are present. There is equally strong evidence for believing that during the tertiary stage the parent does *not* infect his offspring. I know instances of men who had contracted syphilis before marriage, and had been imperfectly cured, and had for many years (ten, fifteen, or even twenty) occasionally suffered from outbreaks of cutaneous syphilides, gummata, and other varieties of the advanced form of the disease, and yet have been the parents of perfectly healthy children, and have never infected their wives. Cases have, however, been recorded in which the wife and her offspring have been affected after very long periods, extending even to ten or twelve years, even when no evident signs of the disease were present in the parents; and, on the other hand, marriage at two years after infection has frequently been followed by the production of healthy children. When, therefore, the question is put to the Surgeon, when may a patient marry who has suffered from constitutional syphilis, it is by no means always easy to give a direct and immediate answer. In answering the difficult question that is thus frequently raised, the Surgeon must be very cautious; he must bear in mind that the health and happiness of a woman and the future of a family are often dependent on his reply; and that, should he give his consent to the union and evil consequences follow, the whole responsibility will be thrown upon him. It may be generally stated in the first place, that if any of the local symptoms of syphilis are developing themselves, the affected person should not marry, whatever time has elapsed since the commencement of the attack. As a general rule, even if all local symptoms have disappeared, it is advisable not to marry till three years after the commencement of the disease. If, however, there are reasons which make it difficult to delay so long, the Surgeon may give his consent to the patient's marrying at two years after the time of infection, provided he have shown no distinct symptoms of active syphilis in the preceding twelve months. Marriage under two years is most frequently followed by the production of diseased children, and should never be consented to unless the attack has been of a very slight character and no symptoms have been observed for a year.

PROGRESS OF ACQUIRED SYPHILIS. **First Stage. Period of Incubation.**—The effects of contagion are not immediately manifested. The time that intervenes between inoculation and activity of the poison is called the *incubation period*. It may be occupied in three ways. If the vehicle containing the virus be of a non-irritating character, the broken surface heals, and all trace of the inoculation disappears until the incubation is completed: or, as the vehicle of the virus is often pus or discharge of an irritating kind, it may cause immediate inflammation at the point of inoculation. This irritation subsides in a short time, and the part then remains quiet until the incubation is complete, when the syphilitic poison betrays its presence by

characteristic phenomena. An experiment of Vidal's illustrates this: he inoculated the matter of a pustular syphilitic eruption on the arm of a medical student, which produced a pustule in a couple of days; this healed over in about a fortnight, and the experiment was supposed to have failed until the thirty-fifth day; action then recommenced by the development of a papule, which subsequently ulcerated, and general syphilis followed in due course. If the syphilitic virus be carried in the pus of a local contagious chancre, the time of incubation is often occupied by the course of a chancre, which may or may not have healed over when the syphilitic poison begins its action. This series of events, first a suppurating contagious sore, and then induration forming in the base of the sore, or in its scar if the sore have already healed, is perhaps almost as common as the inoculation of syphilis unaccompanied by immediate local irritation; but the two morbid processes have no connection with each other, and are only accidentally co-existent.

The length of this time of inactivity varies in different persons; it is commonly twenty-five days. The shortest known period before the poison began to reveal its presence has been ten days, and the longest forty-six days. The most important question with regard to this stage of the disease is, how long does the poison remain localized at the seat of inoculation before entering the circulation? No certain answer can be given to this question, but it is probable that the period between inoculation and general infection is very short. Berkeley Hill records a case in which he freely destroyed the surface of the wound left by a rupture of the frænum about twelve hours after infection, but in spite of this general syphilis followed. Ricord, who at one time believed that destruction of the seat of inoculation within five days would prevent the general disease, afterwards completely abandoned this view, and came to the conclusion that destruction of the seat of infection is useless. Experiments on the inoculation of vaccine lymph on the human subject, and the virus of glanders on horses, have shown that the time that elapses between the local introduction of the virus and its entrance into the circulation is very short. In glanders, the excision of the seat of inoculation one minute after the poison was inserted, failed to arrest the development of the disease. Those cases, therefore, in which general syphilis is reported to have been cured by excision of the primary sore cannot be accepted without further evidence.

Second Stage. Appearance of the Initial Manifestation or Primary Sore.—When the period of incubation is past, a peculiar chronic inflammatory process accompanied by the growth of new tissue takes place, in the seat of inoculation beneath the epithelium, if that be intact, or in the tissues forming the base of the ulcer, if the inoculation has been immediately followed by the formation of a sore consequent upon the simultaneous introduction of the poison of the non-infecting chancre or other irritating matter. Should such a sore have healed, the new growth commences in the scar. The new tissue is of almost cartilaginous hardness. Microscopic examination shows it to be formed by an infiltration of the connective tissue with small round cells. With these larger cells containing a single nucleus are found, and not uncommonly multinuclear cells of considerable size are met with. These differ from the giant-cells of tubercle in being smaller and more regular in outline. It is the formation of this growth that forms one of the most distinctive features of the true syphilitic sore. The simple chancre is formed by a true process of ulceration. There is destruction of tissue from the

first, and such apparent increase as there may be results merely from inflammatory exudation, and the cells infiltrating the tissues are apparently all migrated white corpuscles, and show no signs of higher development. In the initial manifestation of syphilis, in addition to the small round cells, larger cells evidently undergoing development are met with. In the simple chancre there is from the first evident loss of substance; in the hard sore there may be distinct increase of tissue even when ulceration is taking place. The new growth in the initial manifestation of syphilis is imperfectly vascularized. The walls of the small arteries and veins in the infected tissue are sometimes found to be thickened, and the lumen obstructed by a growth from the endothelium. Consequently the indurated tissue tends readily to degenerate and break down.

Clinically the initial manifestation assumes two forms, the desquamating papule, and the indurated chancre.

The **desquamating papule** appears at the point of inoculation as an elevated hard dark-red or copper-coloured spot distinctly elevated above the surface, with slight desquamation of the epithelium covering it. At first it is very small, but may gradually extend till it reaches half an inch in diameter. It is dense and hard, its edges are sharply defined; it is practically painless, causing at most a slight itching. It occurs most frequently where it is little exposed to friction or to the irritation of accumulated secretions. If irritated in any way it readily ulcerates and then becomes an indurated chancre. In fact it rarely remains as a papule to the end. From its painless nature it may run its course and subside without attracting the attention of the patient.

The **Indurated or Hunterian Chancre** commences as a papule, or may begin as an apparently simple sore which becomes indurated when the period of incubation is past. It assumes two forms dependent on the amount of the surrounding induration. In one form the sore is superficial, and the hardness, which is clearly defined, extends but little beyond it. In this variety, the sore is the most prominent feature, and the induration may even be difficult to detect, sometimes assuming the form described by Ricord as "parchment induration." The discharge, if the sore be kept clean and free from irritation, is merely serous, and under the microscope shows granular *débris* with a few epithelium scales. If the surface be irritated by dirt, or by any substance used as a dressing, it rapidly becomes purulent. The extension of the ulceration is slow and painless. The superficial sore forms the most common variety of the initial manifestation. It occurs usually on moist surfaces as the glans or inside of the prepuce in the male, or labia in the female.

The second form of indurated sore is that most properly described as the "true Hunterian chancre." It is surrounded by a dense mass of induration extending deeply into the tissues. It is considerably elevated above the surrounding parts, and the surface is often cup-shaped. Grasped between the fingers it feels almost like a piece of cartilage, the limits of the induration being clearly and sharply defined, and the surrounding tissues free from inflammation. It is usually painless, and its surface is often almost dry, there being merely a very slight serous discharge. It is most common on the glans or on the corona. Every modification may be met with between these two forms of the indurated sore. It has been maintained by Surgeons of great authority that induration at the site of inoculation may occasionally be absent.

It is certainly in some rare cases so slight that it is detected with difficulty, but it is doubtful if it is ever wholly wanting.

As soon as the primary sore makes its appearance, the patient acquires an immunity from re-inoculation of the poison, the discharge from an indurated sore not being inoculable on the patient himself under ordinary circumstances. If, however, the surface be irritated mechanically, by the application of irritating dressings, or from want of cleanliness to such an extent that the discharge becomes purulent, it will then as a rule become auto-inoculable, the resulting sore resembling a soft chancre in appearance, and not presenting the characteristic feature of the hard chancre. The non-inoculability of the discharge from an inflamed hard sore has been used as a means of diagnosis between the hard and soft chancre, but in cases in which doubt existed the sore would probably be suppurating from irritation, and consequently an error might easily arise.

Number.—The primary syphilitic sore is almost invariably single. This fact is readily explained by its non-inoculability on the patient himself. Arthur Cooper states that of 103 cases of early syphilis admitted into the Male Lock Hospital, in 91 there was only one initial lesion, 7 had two sores, and five had more than two. The indurated primary ulcers of syphilis are most frequent on the *genitals*, but not so exclusively limited to those parts as are local venereal sores, because syphilis is communicated in various ways besides that of sexual intercourse. They may appear on any part of the body. Fournier found that, of 472 cases of inoculation in men, 314 were on the prepuce and glans penis, 109 on other parts of the male organ, 12 only on the mouth, 6 on the hands and fingers, and a few on the eyelids, tonsil, and navel.

The **Urethral Chancre** is usually situated just within the orifice of the canal, and may be seen on pressing open its lips, in the form of a small sore, which occasionally creeps out upon the glans. Sometimes it is more deeply seated, so as to be out of sight; when this is the case, a discharge, occasionally tinged with blood, appears in small quantities from the urethra; at a little distance up the canal there will usually be felt, on grasping the organ between the fingers, a circumscribed indurated spot, which is somewhat painful on pressure and after micturition. It is the presence of chancres in this canal that formerly led to the supposition of the identity of syphilis and gonorrhœa, an error which was disproved by the test of inoculation; the discharge from urethral chancre producing the typical sore, that from gonorrhœa giving no result when introduced into the skin. The existence of chancre within the urethra may be suspected if the urethral discharge be small in quantity, serous in character, and tinged with blood. The chancre may be detected by everting the edges of the urethra, or, if situated too high up the canal to be seen, by being felt hard and nodulated through its coats.

In some cases of disgusting depravity chancres are met with at the margin of the **anus**. In this situation they present nothing peculiar.

In **women** chancres are very rare on the vaginal wall, about four per cent. are said to occur on the cervix uteri, and the remainder on the external organs of generation.

Labial and **Facial Chancres** are by no means uncommon, being most frequently the result of the inoculation of some small crack on the lip or excoriation of the skin of the face with the discharge from mucous tubercles in the mouth of an infected person. Chancres on the lip may possibly result

also from drinking or using a spoon after a syphilized person, or smoking the same pipe. These chancres are often very deceptive, the raised and indurated base causing them closely to resemble epithelioma. In a case of chancre of the cheek lately admitted into University College Hospital, the sore was as large as a half-a-crown, and raised abruptly above the surrounding skin for about a quarter of an inch. The sore was but slightly indurated, and the discharge was serous and bloody, mixed with a little pus. The surface had a great tendency to become covered with scab. In other cases the induration may be of the same character as in the Hunterian sore on the penis. The diagnosis can usually be made without difficulty by attention to the foul surface, hard base and persistent character of the sore, and by the invariable presence of indolent enlargement of the lymphatic glands from its earliest appearance. Later on the appearance of skin-eruptions will make the nature of the case evident. From cancer labial chancre can usually be distinguished by the age and sex of the patient, as it is most commonly met with in girls and young women who have not reached the age for cancer ; indeed, in women at any period of life cancer of the lip is extremely rare. Chancres have been met with even on the **tongue.**

I would especially caution the Surgeon not to be misled in his diagnosis by the modest look or the respectable station in life of the infected woman. In this, as in all other cases of venereal disease, he must make an independent diagnosis without regard to social considerations or to the statement, often purposely misleading, made by the patient.

Syphilis not unfrequently occurs amongst Surgeons and accoucheurs as a consequence of inoculation on the **fingers**, during the dressing of a venereal sore, or the delivery of a diseased woman ; and is occasionally met with also among non-professional persons. It usually appears as a small sore by the side of the nail and under its matrix, with much swelling, redness, and pain in the finger, which becomes bulbous : pain and swelling of the axillary glands soon follow. If the nature of the disease be not recognized, the ulceration will creep round the tip of the finger, have a foul and sloughy look, with exquisite tenderness, and, resisting all ordinary treatment, may be set down as malignant ; on which supposition amputation of the finger has been proposed and practised. I have seen at least four cases in which this extreme measure has been proposed, but in which, by a timely discovery of the true nature of the affection, the finger was saved.

Variations in the Sore as the result of Irritation.—As the result of irritation, the normal serous discharge of a hard chancre becomes purulent. If the irritation be more severe, and especially if inefficient caustics, as nitrate of silver, have been applied, the surrounding tissues become infiltrated and swollen so as to obscure the characteristic sharply defined edge of the induration. In such cases it is often impossible to make a diagnosis until the inflammation has been subdued by proper treatment.

Hard sores rarely if ever assume a sloughing form. Phagedænic ulceration is, however, not uncommon (*vide*, p. 1070).

Prognosis from the Appearance of the Primary Sore.—Every patient who has the initial manifestation is already suffering from constitutional syphilis, and nothing can prevent his suffering from secondary symptoms. These may be so slight as to be scarcely noticeable, or so severe as to endanger life. Much induration is often thought to precede a severe course of syphilis,

and possibly this may be true; but the most severe symptoms have also followed small superficial sores, so that it is not safe to draw any conclusion from the appearance of the initial manifestation.

Course of the Indurated Sore.—If unmodified by treatment the initial manifestation tends slowly to disappear, the surrounding induration melting away and the sore healing, a scar being left behind, which is more or less marked, according to the extent and depth of the ulceration that has accompanied the process. The simple desquamating papule may leave no recognizable scar. The length of time which may elapse before spontaneous disappearance of the induration takes place is uncertain, but it is rarely, if ever, under two months.

Indolent Enlargement of the Lymphatic Glands.—The so-called *indolent bubo* is the next change to follow induration at the seat of inoculation. The time at which this follows the appearance of the initial manifestation is variously stated at from seven to eleven days. Most commonly the glands are found already enlarged when the patient first presents himself, and form an important element in the diagnosis. One gland enlarges first and several follow; the glands are painless, or only very slightly tender, and the hardness is such that they are often described as feeling like bullets. The skin over them is unaltered in appearance, and the individual glands can be clearly distinguished, even when they form together a considerable mass, there being no doughy swelling about them as in the acute suppurating bubo. In rare cases, if the sore be irritated so that it is suppurating freely, or if the patient has unwisely taken violent exercise, as dancing, riding, and the like, suppuration may take place, and an abscess form around the glands. The pus, however, from such an abscess is never auto-inoculable like that from the virulent bubo following a soft chancre. If the point of contagion be situated near the middle line, at the frænum for instance, the glands in both groins are often enlarged.

SECONDARY AND TERTIARY CONSTITUTIONAL MANIFESTATIONS OF SYPHILIS.

In describing the constitutional manifestations of syphilis it will be most convenient to give first an outline of the general pathology and the ordinary course of the disease and its treatment, and subsequently to consider more in detail the special syphilitic affections of the various textures and organs.

General Pathology and Progress of Syphilis.—After the appearance of the initial manifestation there is usually an interval of from five to seven weeks before any further characteristic symptoms are developed. This has been termed "the period of second incubation." During this time there is in most cases some disturbance of health; the patient becomes pale, and suffers from malaise or a general sense of indisposition, often with some loss of flesh. Neuralgic pains in the head and other parts of the body are common during this stage. Sometimes there is distinct but slight febrile disturbance just before the cutaneous eruptions make their appearance, but this is seldom sufficiently marked to attract attention.

At the end of this period, often before the primary sore is healed, the secondary manifestations of the disease make their appearance. These consist of various superficial affections of the skin and mucous membranes, usually appearing more or less symmetrically. In the skin the early syphilitic

eruptions or syphilides present the following gradations. In the simplest form there is hyperæmia of the papillæ in localized spots with some retardation of the blood-stream. We consequently get a red patch of a somewhat dusky colour not perceptibly elevated above the surface. On pressing on the discoloured area the red tint disappears, a faint brownish or copper-coloured stain is left behind. This is presumably due to staining of the tissues by the pigment from a few corpuscles which have escaped from the distended vessels. This form of eruption is described as macular syphilide, syphilitic roseola. It is the most common and the earliest of all the cutaneous affections. It occurs also on mucous membranes, and is usually of short duration.

If the hyperæmia continues for a longer time, the papillæ become swollen and an increased growth of epithelium takes place on their surface. There is thus formed a red patch, slightly elevated and covered with a branny or scaly layer of desquamating epithelium. This is the squamous syphilide or syphilitic psoriasis, a common early syphilitic eruption. If the eruption occurs in a moist place, as in the neighbourhood of the anus or on a mucous membrane, the hypertrophy of the papillæ is usually more marked, and the new epithelium instead of forming dry scales separates early or forms a sodden white mass on the surface of the patch. Occasionally the papillary aspect of the growth is very distinct. This is the mucous tubercle or flat condyloma, and when the eruption is general every gradation may be traced between it and the squamous syphilide, according to the degree of moisture of the part in which the patch is situated.

The next degree of the process is the syphilitic papule or papular syphilide. This is the result of a coagulable inflammatory exudation into the papillæ of the skin. It forms a hard, red, elevated patch, usually of small size and covered by a bran-like desquamation of the epithelium. It merges insensibly into the squamous syphilide, or, if in a moist part, into the mucous tubercle.

If the process be more acute, the serum from the exudation raises the cuticle and a vesicle is formed. Vesicular syphilide is a rare form of eruption. Should it be still more acute, migrating corpuscles penetrate the Malpighian layer of the epithelium, and mixing with the serum in the vesicle, convert it into a pustule, and there is then developed the pustular syphilide. When the pustules occur in the early stages of syphilis, they dry up and form scabs, beneath which no ulceration takes place, and no scars are left when they are healed. On mucous membranes, from the thinness and softness of the epithelium, the superficial layer is very early cast off, and there is thus formed the small superficial ulcer commonly met with on the tongue and lip.

All the early syphilitic eruptions are merely modifications of one pathological process, differing in degree but not in nature. They occur in all parts of the body, and often in situations which are not affected by simple eruptions of the same character; thus, for instance, the squamous syphilide is common on the palms of the hands, the soles of the feet, and the flexure of joints. They present also the great peculiarity of causing little or no itching or irritation. More than one form of eruption may be present at the same time, and in this again, they differ from simple skin diseases.

With the skin-eruptions there is, in the majority of cases some affection of the throat. With the roseola of the skin there is usually some redness and dryness of the fauces, as if a similar eruption was taking place there also. Later on ulceration of the tonsils very commonly takes place. The ulcers are,

as a rule, symmetrical; they have sharply-cut edges, and a grey floor, and the mucous membrane round is reddened. They cause singularly little pain in most cases, and have no tendency in this stage of the disease to extend far beyond the surface of the tonsil, or to cause extensive destruction of the pillars of the fauces or soft palate.

The remaining symptoms, belonging to the secondary stage of the disease are, loss of hair, pains in the bones, periostitis without any tendency to terminate in suppuration, caries or necrosis, and inflammation of the iris.

The most constant of the foregoing symptoms are the roseola followed by papular and squamous syphilide, with ulceration of the throat; mucous tubercles, loss of hair, and periostitis are common but by no means constant; iritis is, fortunately, met with only in a small percentage of cases of syphilis.

During the time the eruptions are making their appearance chronic enlargement, with induration of the lymphatic glands throughout the body, is not uncommon. The patient is usually anæmic and thin, but not necessarily so.

The secondary stage may end in two months or extend over a year. When it has come to an end the patient may never suffer again from any symptoms of the disease, or he may pass on directly to the development of those symptoms which are classed as tertiary. In typical cases an interval of months or years may intervene between the tertiary and secondary stage, during which occasional relapses of the secondary symptoms may occur. In other cases, again, the tertiary affections may appear before the secondary signs have subsided. Thus there is no distinct line of demarcation between secondary and tertiary syphilis.

The tertiary stage of syphilis is characterized by the appearance of ulcers on the skin, and mucous membranes, usually unsymmetrical, and having a tendency to spread widely, and to cause considerable destruction of tissue; by certain chronic degenerative changes in the blood-vessels; by chronic fibroid induration of organs and tissues, and by the development of masses of new tissue forming definite tumours prone to early degeneration—syphilitic gummata or syphilomata.

The *ulcers on the skin* begin in various ways. First, they may arise in much the same way as the secondary eruptions. A localized patch of the skin, a quarter of an inch or more in diameter, becomes inflamed, usually vesication takes place, the fluid in the bleb becomes rapidly purulent and then dries up, leaving a dry adherent scab which gradually increases in thickness and diameter. If this be removed, a circular ulceration of the cutis is found beneath, which may slowly spread with the formation of a fresh scab. This form of eruption, known as *rupia*, occurs scattered over the whole body, and in this resembles a secondary eruption. In fact, it forms an intermediate link between secondary and tertiary affections.

Secondly, small gummata form in the cutis vera, forming flat dusky-red or copper-coloured elevations, known as tubercular syphilide, or syphilitic tubercles. These soften in the centre, and an ulcer forms which may spread slowly.

Thirdly, a gumma may form in the subcutaneous tissue; which softens, becomes adherent to the skin, and opens on the surface by ulceration, leaving a deep excavated cavity, with an adherent yellow slough.

Lastly, in syphilitic subjects, a simple injury to the skin may lead to

a spreading ulcer. This form is most common on the leg. All tertiary ulcers tend to spread slowly, often extending on one side while healing on the other. They thus are often crescentic or serpiginous in form.

The *changes observed in the smaller arteries* consist of a gradual narrowing of the lumen by a growth apparently originating by proliferation of the endothelium. The external coat is also thickened, but in a slighter degree. These changes have been observed in the cerebral and renal arteries of medium size, and in the smaller vessels in the neighbourhood of gummata. In the larger arteries no distinctive changes are met with, but it is a well-known fact that the great majority of aneurisms of the larger vessels in young subjects occur in those who have suffered from constitutional syphilis.

Overgrowth of the connective tissue is met with in the lung, liver, spleen, testicle, and other organs, and with it must be classed the diffuse hypertrophy of bone, which is not an uncommon consequence of syphilis. An organ affected in this way is tougher and harder than natural, and at first increased in bulk. If it is inclosed in a fibrous capsule, as the liver or testicle, this is thickened and opaque, sometimes uniformly, sometimes in patches. When the organ is covered by a serous membrane this also shows signs of chronic inflammation ; thus a syphilitic lung or liver always shows firm fibrous adhesions between the visceral and parietal layers of serous membrane. A testicle is almost invariably surrounded by a hydrocele often divided into separate sacs by adhesions between the visceral and parietal layers of the tunica vaginalis. In a later stage the affected organ may shrink and become puckered on the surface. A section shows, in the early stage of enlargement, that the proper structure is infiltrated by a whitish or semi-transparent material of considerable firmness lying in the natural situations of the connective tissue and following the lines of the vessels. In the testicle the septa may thus be increased to half a line or more in thickness. In the later stages, when the active process has ceased, dense cicatricial bands of fibrous tissue may pass through the organ in various directions leading to puckered scars on the surface. The process is painless, and the performance of the natural function of the organ is diminished in proportion to the destruction of its proper structure by the pressure of the new growth.

The microscopic appearances presented in organs thus affected are those of chronic interstitial inflammation. The interstitial connective tissue, sometimes throughout the affected organ, sometimes in bands or patches, is found to be infiltrated with small round cells, about the size and shape of white blood corpuscles. Between the cells is a delicate stroma, usually finely fibrillated. Vessels of new formation are abundantly present in the new tissue. The growth seems to commence round the vessels and to infiltrate along their course. At a later stage it becomes developed into dense fibroid tissue, and at the same time undergoes considerable contraction, and this may lead to deformity and puckering of the affected organ. The normal structures of the part are pressed upon by the growth, and may degenerate and be completely absorbed in parts. The original vessels show the changes just described, and are frequently obliterated.

This process manifests itself in bone by a gradual enlargement extending over a considerable area, and accompanied by a great increase in density of the structure (sclerosis of bone). The Haversian canals are narrowed, and in

many are completely obliterated, and thus from want of blood-supply death of a portion of bone may take place (syphilitic necrosis). The bones of the skull furnish some of the best specimens of this change.

The most characteristic pathological product of tertiary syphilis is the *gumma*, or as it is sometimes called the *syphiloma* or *syphilitic granuloma*. A gumma commences by a localized process essentially similar to the diffuse form just described, namely, an infiltration of the connective tissue of the affected part, with small round cells. These cells may be in part migrated white corpuscles, and in part formed by proliferation of the original connective tissue corpuscles. It is impossible to say to what extent they owe their origin to these two sources. New vessels are formed amongst the cells, and thus a tissue is developed having the characters of granulation tissue. This continues to increase in quantity till the special structure of the part, such as epithelium in a gland, striated fibres in muscle, fat cells in adipose tissue, or the compact tissue of bone, disappear in the affected area, being destroyed and absorbed in consequence of the pressure of the invading growth. Thus a nodule is formed, composed of small round cells, between which is an intercellular substance, small in amount and usually distinctly fibrillated, so as to give the new tissue considerable toughness. The gumma in this stage is abundantly vascular. The new tissue exceeds in bulk that which it has replaced, and thus forms a distinct tumour. It increases by a progressive infiltration of the surrounding structures, and not, as in tubercle, by the formation of new nodules, which coalesce with that first formed. The growth continues till the gumma may reach the size of a walnut ; but long before this —in fact soon after the gumma becomes recognizable—degenerative changes have taken place in its structure. These arise, not, as in tubercle, from the absence of vessels in the new tissue, but, as has been pointed out by Greenfield, from a gradual obliteration of the small arteries entering the mass by the process, already described, of proliferation of the endothelium and thickening of the external coat. Probably also the pressure of the new cells, closely packed together, obstructs the circulation through the capillaries. As a result of the starving of the new tissue thus brought about fatty degeneration takes place. The cells wither and become filled with fat granules, and finally are represented merely by fatty *débris*, amongst which the individual elements are not recognizable. The intercellular tissue, when fibrillated, undergoes but little change, and thus the caseous mass retains a considerable degree of toughness, very different from that of yellow tubercle. The caseation may follow very closely on the growth ; but while growing a gumma is always surrounded by a zone of cell-infiltration of the neighbouring connective tissue, with vessels of new formation amongst the cells. The caseated centre of an old gumma often contains crystals of cholesterine. Gummata vary somewhat in consistence according to the degree of fibrillation of the intercellular substance. In some cases mucous softening seems to take place and the gumma may be almost gelatinous in consistence.

The ultimate fate of a gumma varies in different parts and under different circumstances. Even after caseation and partial softening it may, under proper treatment, be completely absorbed, leaving a depressed fibrous cicatrix behind it. In other cases, especially in gummata of the subcutaneous tissue, bone and muscle, softening takes place, followed by suppura-

tion round the softened mass. The pus finally reaches the surface, and the tissue of the gumma is cast off as a slough. The slough is tenacious and slow to separate even after the pus has been discharged. It has been very aptly compared to a piece of wet wash-leather. In this it differs entirely from caseated tubercle, which, when under similar circumstances, forms a granular mass which can be readily scraped away with a sharp spoon. In the liver, testicle and brain growth may cease, and the surrounding zone of cell-infiltration, instead of degenerating, may be developed into a fibrous capsule, which may enclose the caseated mass and completely encyst it. In this condition it may remain permanently without causing further mischief. Calcification occasionally takes place, but is far from common.

A fully developed gumma, free from softening, presents to the naked eye on section the following appearances. The cut surface is smooth, of a pale straw yellow colour, of tough consistence, and on scraping yields but a small amount of granular *débris*, sometimes scarcely any. Though its outline is tolerably well defined, it can always be seen that the growth is not circumscribed, but is surrounded by a greyish semi-transparent or opaque zone infiltrating the surrounding tissues, and often sending processes in various directions along the lines of the vessels for some distance. The organ in which it is situated is, in many cases, the seat also of general interstitial fibroid induration.

From the above description it will be seen that a gumma resembles tubercle in being a new growth of the type of granulation-tissue, prone to early fatty degeneration, followed often by softening and elimination by suppuration. It differs from tubercle in being vascular during the whole stage of evolution, in its capability of being absorbed or of undergoing a development in part into fibrous tissue, in the toughness of its tissue, and in the absence of the characteristic tubercle follicle or nodule, with its giant-cell, epithelioid cells, lymphoid corpuscles, and reticulated stroma.

Clinically in those parts in which a gumma comes under the observation of the Surgeon, it forms an indolent tumour of slow growth, often accompanied by a good deal of aching pain. If superficial it slowly approaches the cutaneous surface, the skin becomes adherent, and then dusky red. The mass softens and fluctuates distinctly, and an opening forms from which some thin unhealthy pus escapes. This gradually increases in size by ulceration in many cases, till the whole reddened skin is destroyed. The tissue of the gumma is seen as an adherent, tough slough, like a piece of wet wash-leather, which slowly separates; the cavity becomes lined with healthy granulations, and heals without difficulty, leaving a deep cicatrix. If a bone be affected, a carious patch is left, sometimes complicated by the presence of sequestra of varying size. Small gummata, not more than one-quarter of an inch in diameter, may form in the cutis vera, and afterwards soften and run the same course as deeper and larger growth of the same kind. In this situation they form the skin disease known as *tubercular* syphilide. Gummata do not necessarily cause any enlargement of the neighbouring lymphatic glands, though this may occur when softening and suppuration are taking place.

Gummata will be further referred to with the organs in which they are met with.

Gummata have been occasionally met with in an early stage of syphilis, and some authorities have maintained that the processes concerned in the formation of a gumma differ in no essential respect from these, occurring in

the induration round the primary sore and in the lymphatic glands. There is, however, one essential difference—the discharges from softening gummata are, so far as is known, not infective, consequently it seems probable that the specific virus of syphilis is not present in them. It has therefore been suggested that the changes in the vessels, the diffuse overgrowth of interstitial tissue of organs, and the formation of gummata, are not the direct effect of the virus, but are due to some modification of the mode of growth and nutrition of the tissues, impressed upon them by the poison while it was active in the system. The unsymmetrical character of the later eruptions would indicate that they are not dependent on an active virus circulating in the blood-stream. At present we have not sufficient knowledge of the nature of the virus of syphilis, or of its mode of action, to render these speculations of any real value.

Prognosis.—The severity and form of the manifestations which follow contagion are very various. Diday states that in 93 cases treated by him without specifics, 7 suffered only from a single eruption on the skin, and after that showed no further signs of the disease ; in 53 the disease lasted from ten to eleven months, with eruption on the skin and mucous membranes, occurring irregularly with repeated relapses ; 29 suffered from severe cutaneous eruptions, periostitis, iritis, &c., the average duration of the disease being twenty months ; and in 4 only did the disease assume a grave form with early appearance of tertiary symptoms. Berkeley Hill considers that these statistics form a valuable index of the natural course of syphilis.

The **Circumstances influencing the Progress** of the disease are chiefly the following :—

Age.—Other things being equal, the disease runs the mildest course in young adults. Infants suffer more severely, and after middle life syphilis is very apt to prove intractable. According to some authorities, it is practically incurable if contracted after forty, the patient being constantly troubled by relapses for the remainder of his life.

Sex.—Females are apt to suffer severely, because, from the more concealed situation of the primary sore, they often do not come under treatment till the secondary symptoms are fully developed. Pregnancy usually aggravates the course of the disease.

Personal Habits and Surroundings exert a considerable influence on the course of syphilis. The disease is seen in its worst forms amongst those who suffer from insufficient food, clothing and washing, and are addicted to alcoholic excesses. In a young adult of sound constitution, who leads a healthy and steady life, with plenty of out-door exercise, syphilis is very rarely followed by any of its graver consequences, and usually ceases to give rise to any symptoms in about one year.

The *state of the patient's health* also determines to a great extent the kind of attack he will undergo. In scrofulous or tuberculous subjects the disease usually runs a severe course, and tertiary ulcerations are very prone to occur. In gouty subjects the skin eruptions are very apt to relapse, and periostitis is common. Rheumatism also is said to render the patient prone to inflammations of bones and iritis during the progress of syphilis. Disease of the kidneys is always a most serious complication.

After the symptoms of the disease have subsided, they may again be called into activity by any cause which seriously impairs the general health. It is remarkable for how long a time the syphilitic poison will continue dormant in

the constitution without producing any local manifestation of its existence, until this is developed under the influence of a broken state of health. I have had under my care an extremely severe case of constitutional syphilis, in which twelve years elapsed after the occurrence of the primary disease, during the whole of which time no secondary affection was observed until the patient's health gave way from other causes. And I have also had under my care an officer, in whom a very severe form of constitutional syphilis occurred, for the first time, after salivation for hepatic disease, five years after the primary sore had been contracted—no constitutional manifestation having attracted the patient's notice in the meanwhile. Not only does a state of ill-health hasten the occurrence of secondary syphilis, but neglect or indifference to its existence may keep it up indefinitely.

That the *treatment of the primary sore* exercises considerable influence, cannot be doubted. The severity of the course of syphilis is, I believe, materially lessened by a mercurial course, if that course be properly conducted.

The question as to there being any connection between the *nature of the primary sore* and the character of the consecutive constitutional affection has been much discussed, and very different opinions have been entertained. The generally received opinion at the present time is, that no safe conclusions as to the future course of the disease can be drawn from the appearance of the primary sore. Tertiary symptoms are, in fact, frequently met with in patients who have not a trace of a scar left by the primary sore, and sometimes even in those in whom the initial manifestation has been so slight as to escape notice.

The *character of the secondary symptoms* seems to give a much more valuable indication of the probable course of the disease. A copious early squamous or papular eruption is believed to indicate a quick course, terminating at an early period. Those cases in which the skin disease persists long and frequently relapses, have been observed to suffer but rarely from visceral affections. It is a remarkable fact, noted by Lancereaux, Berkeley Hill, and Wilks, that a large proportion of those who suffer from visceral syphilis have passed through a very mild secondary stage, often so wanting in symptoms as to be scarcely recognizable. This fact is particularly noticeable in tertiary syphiloma of the nervous system. It must not be concluded, however, from these facts that severe tertiary symptoms must necessarily follow a mild secondary stage. It is only when the tertiary symptoms appear that their severity may be said to be in the inverse ratio to that of the secondary. In the great majority of cases a mild secondary stage, when it occurs, forms the end of the disease. Berkeley Hill states, that marked general glandular enlargement is a bad sign, being usually accompanied by anæmia and general debility.

Death from syphilis, directly, during its secondary stage is practically unknown. The disease kills more often by its tertiary manifestations, such as the development of gummata in the central nervous system or liver. Gowers is of the opinion that locomotor ataxy is most common in patients who have suffered from constitutional syphilis. Many aneurisms are believed to be due to syphilitic changes in the vessels. The proportion of cases, however, in which syphilis even indirectly shortens life is so small that it is not considered necessary to make any addition to the premium charged for life-insurance, because a patient has passed through an attack of syphilis, unless some definite tertiary symptoms are present.

Duration of Syphilis.—It is extremely difficult to say when syphilis can be eradicated from the system; and indeed it is a question whether it may not impress the constitution in a peculiar way, modifying certain processes during the rest of life, as we know to be the case in other specific diseases, such as cow-pox or scarlet-fever. Certain it is that, if neglected or improperly treated, it may affect the system for an indefinite time, declaring its existence by exciting and modifying various local inflammations years after the original absorption of the poison. It is tolerably clear that a person who has once had the usual course of syphilis and has recovered from this malady, cannot have it a second time, though he contract a fresh chancre. This rule is from time to time proved to be generally true by the occasional observations of undoubted exceptions, where repetition of the disease from re-inoculation of the virus takes place. But such cases are exceedingly rare, and occur only after an interval of some years has elapsed between the two attacks. Hutchinson has related a very interesting example of this kind in a medical student, who also suffered from two attacks of small-pox. Daily experience shows that in many constitutions syphilis cannot be eradicated, and that in most others, when once it has occurred, it is apt, even when apparently cured, to modify certain cutaneous and other affections in a remarkable manner, after a lapse of many years; showing clearly that, if the poison no longer exist in the system, the constitution has received a peculiar impress from it, which it is long in losing. Sir E. Wilson attributes many of the ordinary non-specific cutaneous diseases to the latent influence of constitutional syphilis.

TREATMENT.—The **treatment of the primary stage** of the disease is local and constitutional.

Local Treatment, which is as a rule all that is required in the simple chancre, is of comparatively little importance in the true syphilitic sore, the causes of the local manifestation being beyond the reach of any direct application. If the initial manifestation assumes the form of the desquamating papule every effort must be made to prevent its ulcerating by the application of some simple non-irritating substance, such as vaseline, to protect it from iritating secretions and friction. Attention to cleanliness by frequent washing is also essential. If an indurated sore forms, iodoform, which is of such singular benefit in the simple chancre, will be found of little use. Attention to cleanliness, the avoidance of all irritating dressings, and the application of a piece of lint soaked in black wash will be found in most cases to be all that is necessary. Caustics are never required, and always injurious. It has been recommended by Ausspitz and others to excise the sore. This treatment was founded on the theory that the virus may be still localized at the seat of infection, and that by removing the initial manifestation the further progress of the disease may be arrested. Experience has shown that it does not produce the desired effect, a fact which confirms the view that the induration of the sore is in fact the first sign of constitutional affection.

Should the sore assume a phagedænic form, it must be treated as already described (p. 1074).

The **Constitutional Treatment** of primary syphilis need not be separated from that of the secondary stage, as the same remedies that favour the healing of the initial manifestation exercise a beneficial influence on the secondary affections. The constitutional treatment of syphilis has undergone various changes according to the prevailing doctrine of the day. It had been decided

by the Surgeons of the last and early part of this century, that mercury acted as a specific against the syphilitic poison. This docrine was so firmly established, that Hunter, and many of the great Surgeons of his school looked on the curability of a sore without mercury as a proof that it was not syphilitic.

About the commencement of this century, however, it was found by observations of the Army-Surgeons, amongst whom Rose took a principal share in the inquiry, that the different forms of venereal ulcer (no distinction being then drawn between the local non-infecting sores and the ulcers which resulted from the contagion of the constitutional disease) were curable without the necessity of administering mercury, or indeed of having recourse to any specific treatment whatever. These observations, which appear to be founded on what was witnessed in Spain and Portugal during the Peninsular War, led to the introduction of an important modification in the treatment of venereal sores; viz., the *non-mercurial* or *simple* plan, as it is termed; a mode of practice that obtained great favour and was extensively tried. On the definite separation of the simple non-infecting chancre from the true syphilitic sore, however, a reaction took place in the minds of most Surgeons, and mercury is now almost invariably employed in the treatment of the latter, and is administered more moderately and scientifically, and consequently more successfully, than before.

The arguments in the favour of the non-mercurial plan of treatment are briefly these: that by this system of treatment the constitution of the patient is saved the introduction of a mineral which occasionally acts injuriously, and which, as the disease can be cured without it, may at all events be looked upon as unnecessary; that secondary affections less frequently follow this plan than they do the administration of mercury; and, lastly, that those distressing cases of constitutional syphilis which are common after mercurial courses, and which are said to depend upon a peculiar combination of the syphilitic poison with the mineral in the system, are never met with in persons who have undergone the simple treatment. These arguments, however, on closer examination and further experience, have been proved to be not quite so conclusive as the supporters of the simple treatment appear to believe. Before the simple sore was clearly distinguished from the initial manifestation of syphilis the early healing of the chancre and the absence of secondary symptoms after it were taken as evidence of the efficacy of the non-mercurial treatment of syphilis. Now that the two forms of sore are clearly separated from each other this fact has of course no bearing on the question, and experience has undoubtedly shown that although the true indurated sore will heal in time without the administration of mercury, yet the process of cicatrization is slow and often imperfect, the scar readily breaking down again for some time after apparent healing; whereas if mercury be given the healing is rapid and permanent. This is, however, but a small part of the question. It is a most serious error to confound the healing of ulcers with the cure of syphilis. The cicatrization of an ulcer and neutralization of the virus are two distinct things; and the test of the relative value of these two plans of treatment must depend rather on the influence they have over the course of syphilis, and on the character that the symptoms assume under one or other of these methods, than on the mere skinning over of the ulcer. I cannot agree with the statement that secondary symptoms are less frequent after the simple than after the mercurial treatment. In fact,

since the separation of the simple chancre from the true syphilitic sore the fact has become clearly recognized that no mode of treatment can prevent the appearance of secondary symptoms; mercury may diminish their severity or delay their appearance, but constitutional syphilis must unavoidably follow the indurated sore, though sometimes the symptoms may be so slight as almost to escape detection.

I have seen the non-mercurial plan of treatment very extensively employed at University College Hospital; indeed, it was formerly almost invariably practised there, more particularly in the syphilitic cases occurring among the out-patients under Morton, who strongly advocated it; and I have had repeated occasion to observe the frequency with which it was followed by secondary symptoms. In private practice, also, I have had considerable opportunities of comparing the two methods, and I can safely say that I have seen the simple treatment more frequently followed by well-marked secondary symptoms than the mercurial plan has been when properly and judiciously employed. The supporters of the non-mercurial treatment, when obliged to admit the great frequency with which it is followed by secondary symptoms, argue that these are less severe after the simple than after the mercurial plan; and they state somewhat dogmatically, and it appears to me without any evidence to support their statement, that mercury and syphilis together form a sort of poisonous compound in the system, which produces the worst and most destructive forms of constitutional syphilis. I deny entirely that we have any proof of the existence of such a combination as that which is supposed to be produced by syphilis and mercury; no evidence with which I am acquainted has ever been induced in support of the formation of such a poison in the system. It is doubtless true that, after an ill-regulated mercurial course, constitutional syphilis of a very severe character may occasionally appear; but this seems to me to be rather owing to mercury having been improperly administered in constitutions that will not bear it, and in which, by the induction of a cachectic and depraved condition of the system, it favours the occurrence of some of the more severe forms of secondary syphilis, in the same way that any other lowering plan of treatment, or simple debility, might occasion them, but without the exercise of any specifically injurious influence. Some of the worst forms of constitutional syphilis that I have seen, occurred in patients to whom no mercury had been administered, but in whom the syphilitic virus had been allowed to exercise its influence unchecked, save by the so-called simple treatment. I have seen the body covered by immense ecthymatous crusts and sores in one case, rupial ulcers with destruction of the nose and palate in another, the worst kind of syphilitic cachexy with the tuberculo-pustular syphilide in a third, and extensive disease of the cranial bones and the clavicle in a fourth; in none of which had any mercury been administered.

But, though I cannot admit that the supporters of the simple or non-mercurial treatment of syphilis have brought forward any proof of its superiority over the mercurial plan, and though my own experience has taught me that secondary symptoms occur after it with no less severity than they do when mercury is carefully and judiciously administered, yet I am quite ready to allow that there are certain conditions of syphilis in which the non-mercurial treatment alone is admissible, the state of the constitution or the disease being such that mercury cannot be given in any form. In these cases such a treatment must be adopted, in accordance with ordinary medical principles, as will

tend to improve the general condition. It is, indeed, especially in individuals of an unhealthy or strumous habit of body, or in those who are suffering from local visceral disease of some kind, especially Bright's disease, or whose powers have been broken by habitual dissipation, that this plan of treatment should be adopted. So also in those who, from the nature of their occupations, are subjected to much exposure to wet and cold, a mercurial course cannot be properly or safely administered, and the simple treatment is most advisable. In all other cases, I am certainly of opinion that mercury ought to be administered; and this opinion appears to be entertained by the most experienced Surgeons of the day in this country and abroad.

The first question in connection with the employment of mercury in syphilis has reference to the principle on which this remedy is administered. Whether mercury exercises a specific action over the poison of syphilis or not, has been much discussed, and is difficult of proof. I certainly think that it does act as a specific in syphilis, but that this action is much influenced by the condition of the system, the habits of the patient, and the mode of administering the remedy; these conditions under certain circumstances tending to counteract or otherwise to interfere with its operation. That mercury is antagonistic to the syphilitic poison, appears evident from the fact that in some instances hard sores will not heal unless it be given internally; from its influence in speedily curing infantile syphilis and preventing after-manifestations in the system; and from the fact that, when properly administered in *healthy constitutions*, it may almost to a certainty be expected to dissipate the various symptoms of constitutional syphilis. When it fails, as it doubtless does in many cases, to prevent severe constitutional symptoms, the failure may usually be traced either to want of care in the administration of the medicine, or to the existence of an impaired state of the patient's health. The essential practical point in the treatment of primary syphilis by mercury is to keep the patient under a prolonged and mild course, rather than a short and active one.

Administration of Mercury in Syphilis.—In discussing this question the following points require consideration. 1. The cases in which mercury is inadmissible. 2. Cases in which it is required. 3. The effects of mercury and the degree to which its use should be pushed in treatment. 4. Its effect in different stages of the disease. 5. The time during which its use should be continued. 6. The mode of administration. 7. The general management of the patient during the time he is taking the drug.

1. *Cases in which mercury is inadmissible.*—As has already been stated, mercury cannot be safely given in scrofulous patients or in those suffering from active tubercular disease. It is especially dangerous in all forms of Bright's disease, so that it is well, if there be any suspicion of an unhealthy state of the kidneys, to examine the urine for albumen before commencing to give the drug. It is not well borne by those also who are exhausted by habits of dissipation, by insufficient food, or by bad hygienic surroundings. Lastly, some patients are peculiarly intolerant of mercury, apparently from some idiosyncrasy, and in these it may be impossible to give it with safety.

2. *Cases in which mercury is required.*—There is no doubt that the natural tendency of syphilis is to spontaneous recovery; this has been clearly proved by the effects of the non-mercurial treatment. In young and healthy adults the great majority of cases would probably escape any serious symptoms if left

without treatment. It is equally certain, however, that mercury shortens the stages and lessens the severity of the disease, and that if carefully administered cannot do any harm. The administration of mercury is therefore advisable in every case of syphilis in which its use is not contra-indicated by one of the conditions above mentioned. As age increases, its use becomes more essential, for, as before stated, the disease becomes more obstinate in proportion to the age of the patient at the time of infection.

3. *The general effects of mercury, and the degree to which it should be pushed in treatment.*—The observations of Liégeois, Hughes Bennett, and Keyes, show that mercury administered to a healthy subject in very small doses acts as a tonic. Under its influence the red corpuscles increase in number, and in animals a gain in weight has been noted. In larger doses it diminishes the red corpuscles. In syphilis, in which the red corpuscles are diminished in number, it causes an increase if administered in moderate doses. All forms of mercury administered by the mouth tend to act upon the bowels, and unless this tendency is checked, the desired alterative effect is not easily produced. The most marked sign of the action of mercury is the effect upon the gums and mouth. The first sign that the drug is affecting the constitution is the appearance of a red line along the gums, close to the teeth; there is at the same time a slight sense of tenderness on biting any hard substance. In the present day the administration of mercury is not pushed beyond this point, and in the primary stage of syphilis, it is not even necessary in most cases to carry it so far before its good effects are apparent on the sore. Should the drug be pushed further, either intentionally or accidentally, the swelling increases; the gums become soft and spongy, and overhang the teeth; the tongue swells, so as to show the impression of the teeth along its sides, and it becomes covered with a thick fur. The breath becomes offensive, and there is an increased flow of saliva, and a metallic taste in the mouth. This condition of "*mercurial salivation*" was in former times regarded as the proper effect to be obtained by the administration of the drug. In the present day it is regarded as an evil to be carefully avoided. If the drug be pushed still further, the teeth may be loosened, and fall out; the gums and tongue may become ulcerated, and acute inflammation may take place in the salivary glands. At the same time there may be considerable febrile disturbance. The effects produced by mercury vary very greatly in different individuals, a dose which would salivate one patient producing no effect on another. In the administration it is necessary, therefore, in all cases, to begin with a small quantity, which may be gradually increased till the patient's dose is ascertained. When symptoms of salivation set in, the mercury must be immediately discontinued. A brisk saline purge may be given, and the mouth must be washed with a strong alum or chlorate of potash gargle (10 to 15 grs. to the ounce of water).

In the treatment of syphilis the effect upon the primary sore is often a useful guide in the administration of mercury. If, under the influence of a certain dose, the sore rapidly assumes a healthy appearance and begins to heal, it may be taken for granted that that quantity is sufficient to act beneficially on the patient, and it may be adhered to during the whole course, even if it does not affect the gums, unless special circumstances require an increase. In fact, it is better in all cases to be guided rather by the effect on the disease than by the effect on the gums. Swollen gums show that the limit of safety

has been reached; if the symptoms are relieved without affecting the mouth, so much the better. There is no evidence that any tolerance of the drug is acquired by its prolonged administration.

4. *The effects of mercury in the different stages of syphilis.*—The effect of the drug on the primary sore is almost invariably very distinctly marked, and manifests itself usually before the gums are affected. The hardness round the sore becomes less intense and less sharply defined. The smooth pale surface becomes of a healthy red colour, granulations spring up, often of a florid tint, and bleeding readily; the thin serous discharge, characteristic of the typical hard sore, is replaced by pus, and by the end of a week or ten days the indurated chancre has assumed the appearance of a healthy granulating sore. As these changes take place, the sore usually becomes more tender and painful, and the patient may become alarmed at what to him seems a change for the worse. The induration at the base of the sore is not usually absorbed for many weeks after the surface has been covered by new epithelium. Simultaneously with the softening of the induration, the glands in the groin become smaller, but they do not, as a rule, reach their normal size and consistence till long after the sore is healed.

The influence of mercury is not, in all cases, so unmistakeable in the secondary stage; but, in most cases, it is evident enough. The rashes fade or diminish in abundance, or may even be entirely prevented, and the sore throat subsides under the influence of the drug. It may be necessary, however, to push the administration till the gums are distinctly affected before the effect is produced. In the tertiary stage its effect is far less certain, and the state of the patient's health is frequently such as to contra-indicate its administration. As a rule, it should not be given unless other means have failed, when it will sometimes be found to produce excellent effects if carefully administered.

5. *The time during which mercury should be continued.*—The administration of mercury should commence as soon as the nature of the disease is recognised, and be steadily continued while the secondary symptoms are making their appearance. Even if no secondary signs appear, it is better to continue the administration uninterruptedly for from four to six months, after which an interval may be allowed. In a young subject, if no signs of the disease are present, its use may then be abandoned, and not renewed unless some fresh symptoms appear. In older patients it is safer to continue the administration of mercury for a year, allowing intervals now and then during the treatment. The patient must be carefully watched, and if any signs of depression from the use of the drug become apparent, its use must be at once suspended. If there be much febrile disturbance immediately before the outbreak of the secondary symptoms, it is advisable in some cases to withhold the drug for a few days.

6. *Mode of administration.*—Mercury may be administered in four ways: (*a.*) by the mouth; (*b.*) by inunction; (*c.*) by subcutaneous injection; or (*d.*) by fumigation.

(*a.*) *By the mouth.*—This, being the most convenient method, is usually adopted. As mercurial preparations are mostly purgative, it is necessary, in most cases, to add a small quantity of opium, to prevent this action. In the treatment of any given case, it is necessary to ascertain what preparation has least tendency to purge the patient, what amount of opium is required just to neutralize the purgative tendency without causing constipation or

headache, and what dose is required to produce the desired effect on the disease. All these points can be ascertained only by observation of the particular case. The form that will be found most generally useful is the following : ℞, grey powder, gr. j.; Dover's powder, gr. j.; extract of gentian, q. s. to make a pill. The patient may begin with three pills a day for three days ; if they give rise to no effects, either beneficial or the reverse, the dose may be increased to four, and after a few days to five, if necessary. Six are very rarely required. If the pill purges, the Dover's powder may be increased ; if it constipates, it must be diminished. A few variations usually succeed in hitting the exact proportions and dose suited to the case, and the prescription may then remain unchanged for weeks or even months. The ordinary blue pill is of the same strength as the grey powder, and may be given instead of it, if preferred ; but it is slightly more apt to purge. It may be first tried alone, or with an equal quantity of extract of gentian, in grain doses, three, four, or five times a day. If necessary, powdered opium or Dover's powder is added. In patients very insusceptible to the drug, as much as ten grains a day of blue pill can sometimes be taken. If these preparations do not suit the patient, the green iodide of mercury, in doses commencing at half a grain, and gradually increased to a grain, three times a day, may be employed. It should be made into a pill with extract of gentian, and, if necessary, a sixth to a third of a grain of extract of opium may be added. The only objection to this preparation is that it may decompose the red iodide and free mercury being formed, it then acts much more powerfully, and may salivate. The perchloride of mercury, or the bicyanide may sometimes be tried if the foregoing fail. They are given in doses of from $\frac{1}{16}$ to $\frac{1}{10}$ of a grain, made up into pills with sugar of milk and varnished. Calomel is never to be recommended, being too irritating. Mercury can also be administered in a mixture, if the pills do not suit. In debilitated constitutions, and in the tertiary stage of the disease, the perchloride in doses of from $\frac{1}{16}$ to $\frac{1}{8}$ of a grain may be given, with compound tincture and infusion or decoction of cinchona. To this are sometimes advantageously added a few grains of iodide of potassium, by which the perchloride is converted into the red iodide of mercury, which is held in solution by the excess of the potassic iodide. Plummer's pill, in five grain doses, twice or three times a day, is very useful in the syphilides.

(*b.*) *Inunction.*—In some cases the bowels are so irritable that the administration of mercury by the mouth invariably purges the patient ; in these circumstances mercurial inunction may be conveniently practised. This is best done by rubbing a scruple to a drachm of the ordinary mercurial ointment into the inside of each thigh or arm or in the axilla before going to bed. The skin should be well washed before the mercury is rubbed in. After the inunction the patient should put on flannel clothes next his skin to encourage sweating, and go to bed. In the morning he should take a hot bath. The inunction must be repeated daily till some effect is produced, and it is best not to rub the ointment into the same part on two consecutive days. It must be borne in mind that the orifices of the sweat-glands and hair-follicles become filled with the ointment ; so that, should salivation commence, it is not easy at once to arrest the absorption of the mercury. The use of the hot bath every morning diminishes the risk of the absorption of an undue amount.

(*c.*) *Subcutaneous injection* of mercury has been employed by Lewin and other

Surgeons on the Continent, and by Walker of Peterborough in this country. The salt used is the perchloride, of which about one-sixteenth of a grain is injected in solution in 30 minims of water. Sigmund of Vienna, who tried this remedy in two hundred cases, used a solution of about four grains to one ounce of water to which he added eighty grains of common salt. He insists strongly on the necessity of rest after the injection, so as to obviate the occurrence of abscess and other untoward consequences which have been observed to follow it. The precise value of the subcutaneous injection of mercury in syphilis has, it seems, yet to be determined. Sigmund believes it to be most useful in those forms of the disease affecting the more superficial structures and the osseous, muscular, and fibrous tissues. Hill, who has extensively tried this mode of administration, is of opinion that it should be reserved for those rare cases in which mercury cannot be taken in the more ordinary ways.

(*d.*) *Mercurial fumigation.*—In some cases of constitutional syphilis in which the patient cannot tolerate this drug by the mouth, mercury may conveniently be administered by fumigation. This plan of treatment, which has been especially recommended by Langston Parker and H. Lee, consists of a combination of vapour-bathing and of mercurial fumigation ; and these gentlemen speak in the highest terms of the value of this remedy in syphilis, as shortening the duration of ordinary treatment, and permanently curing the disease without the constitution of the patient being in any way injured by its employment. The baths may also be associated with appropriate internal treatment. Fumigation is thus carried out ; the patient is seated naked on a wood-bottomed chair or stool and is covered by a cloak made of some thick woollen material reaching to the floor and fastened round the neck. It is fitted with a cane hoop to keep it from touching the body. A lamp consisting of a circular trough to contain about one ounce of water, and a central plate for the mercurial preparation, is used for producing the vapour. The water must be made to boil thoroughly before the mercury is put on the plate. It is then immediately put under the chair, and thus the patient's body will be steamed for a minute or two before the mercury begins to volatilize. The best form of apparatus is that known as Lee's lamp, but in the absence of all special apparatus fumigation can very easily be carried out by means of two spirit-lamps and two metal vessels, one for the water and one for the mercury, the patient being covered by a thick blanket. Various forms of mercury have been used, but the two best seem to be the bisulphuret as recommended by Langston Parker, in doses of from one to two drachms at each bath, and calomel, which has been extensively used by Henry Lee in doses of from twenty to thirty grains. Whatever form of apparatus be used, after about twenty minutes, when the whole of the mercury will have been volatilized, the patient gets into bed wearing the cloak or blanket. He must not be left alone during the bath, as he may become faint. If perspiration does not begin at once a little weak hot tea may be given to encourage it.

7. *General management of a patient during a course of mercury.*—The patient should be made to understand clearly that mercury does not directly cure the disease, but only aids the system in overcoming and eliminating the poison. Regular hours, sufficient exercise in the open air, abundant simple food, and the avoidance of alcoholic or other excesses are of equal importance in the management of a case of syphilis as the administration of mercury. While

the patient is under the influence of mercury the skin should be kept in a healthy state by baths. In summer there is no objection to a morning cold bath, but in winter some warm water should be added to prevent a chill. The patient should wear flannel next his skin both in summer and winter. A chill during a course of mercury may cause a violent attack of diarrhœa, sometimes accompanied by much griping pain and vomiting. The diet should be plain, and anything likely to irritate the bowels, as excess of fresh fruit or made dishes, should be avoided. Beer is usually not to be recommended, as it is apt to cause purging. Claret is perhaps the best alcoholic drink that can be taken. All these things must, however, be left, to a certain extent, to the common sense and experience of the patient. Moderate exercise is of the greatest value, but should not be carried to the extent of fatigue.

Other Drugs used in the Treatment of Syphilis.—In the primary and early secondary stages of syphilis no drug but mercury can be said to exert any real influence on the disease ; but in the later secondary and tertiary stages the *preparations of iodine* produce effects not less clearly marked. Iodine is supposed to be a specific in a minor degree to mercury. It has also been proved that in patients who have undergone a course of mercurial treatment iodine liberates the mercury which may have become stored up in the body, the mercury re-appearing in the urine and other secretions on the administration of the drug. Its effects are not, however, due to this, for they are well marked in patients who have never taken any mercury during the early stages. The preparations of iodine are most useful in the various forms of visceral syphilis, in syphilitic disease of the nervous centres, and in treatment of gummata wherever they may be situated. Useful as iodide of potassium is, however, I do not believe that syphilis can be eradicated from the system by its means ; indeed, I cannot call to mind a single case presenting marked tertiary symptoms which has been permanently relieved without the administration of mercury.

Iodine is commonly administered, as Iodide of Potassium, in doses of from five to twenty or even thirty grains. It is often conjoined with some bitter infusion, but there is no advantage in this unless the patient requires a tonic. A most convenient mode of giving iodide of potassium is the following : Take a two-ounce bottle, put into it one ounce of the iodide and fill it up with water ; let the patient take eight drops of the solution in a wineglass of water or in milk three times a day, and gradually increase the dose by two drops every two or three days till he finds by the symptoms of iodism that he has reached his limit. An intelligent patient will soon learn to regulate his dose without the necessity of constantly applying to the Surgeon. The addition of a few drops of aromatic spirit of ammonia is said to make the iodide more active. If the patient is anæmic it may be taken in conjunction with the iodide of iron.

Iodide of Ammonium can sometimes be taken by patients who cannot tolerate the potassic iodide. It may be given in doses of ten grains and upwards, and two or three grains of carbonate of ammonia must be added to each dose to prevent the decomposition of the iodide.

Iodide of Sodium also has been recommended in doses of five grains and upwards. It is said to be less depressing than the potassium salt.

In whatever way iodine is administered if pushed beyond a certain point it

gives rise to toxic symptoms known as "*iodism.*" The amount of the drug required to produce these effects varies with every case. The symptoms resemble a bad cold in the head ; there are redness of the eyes, running at the nose, and frontal headache. Every patient who is taking the iodides must be warned of these symptoms, and be told to reduce the dose immediately they appear. Prolonged administration of iodides not unfrequently gives rise to a pustular eruption resembling acne, or more rarely to large pustules on an indurated base, which dry up, leaving a scab behind them. Purpura and albuminuria have also been attributed to its influence.

The *Sulphides of Calcium and Potassium* are said to form most useful adjuvants to mercury, promoting its action and preventing its accumulation in the system. How much real value they possess is still uncertain. The Aix-la-Chapelle treatment, which has obtained great celebrity for the cure of syphilis, consists of the administration of mercury by inunction, combined with the use of the natural hot sulphur-waters, both for bathing and drinking. The chief advantage derived in most cases from a visit to Aix-la-Chapelle arises from the fact that the patient, having little else to do and being carefully looked after by the physicians and the rubbers, and regularly dieted in his hotel, cannot neglect the treatment as he is too apt to do at home. It is for rich patients who are not taking proper care of themselves that a visit to the baths is to be recommended. A course lasts from six to seven weeks.

Sarsaparilla formerly enjoyed a great reputation in the treatment of syphilis, but at the present time it is little used. It may, however, be given in the late secondary or tertiary stage, especially if the patient have fallen into a cachectic state, having lost flesh, colour, appetite, and spirits. In this condition of the system dilute nitro-hydrochloric acid, in doses of fifteen to twenty minims, with half an ounce of the liquid extract of sarsaparilla in four ounces of water, may be taken three times a day.

Cod-liver Oil is often of great use when there has been considerable loss of flesh. It may be given at the same time as the iodides of potassium or iron.

Bitter Tonics and the *Preparations of Iron* are frequently useful in the tertiary stage. They are given on general principles after or in the intervals of specific treatment.

LOCAL SECONDARY AND TERTIARY MANIFESTATIONS OF SYPHILIS.

Local Secondary Affections.—We shall next proceed to describe the character and treatment of the different *local forms* in which constitutional syphilis manifests itself. These may be considered as they affect different tissues and organs, and require separate examination, according to the part that is influenced by them. We shall consider them as affecting the skin ; the mucous membranes of the mouth, nose, tongue, palate, and larynx ; the eye, bones, testes, muscles, viscera, and nervous system.

1. **Syphilitic Affections of the Skin.**—Syphilo-dermata or Syphilides present various modifications of appearance, corresponding closely to the different groups of simple cutaneous diseases ; thus we find exanthematous, papular, squamous, vesicular, pustular, and tubercular syphilitic affections of the skin, with various ulcers and growths. These differ from the corresponding simple cutaneous diseases, in their redness being more dusky or coppery, in

leaving stains of a brownish or purplish hue, and in their giving rise to no itching or other painful sensations. The general pathology of these affections has been already described (p. 1090).

Besides this, syphilis may modify materially the general character of the cuticle, causing it to assume a yellow or earthy tint, and to be rough or powdery.

Syphilitic skin-diseases arrange themselves under the following groups.

Syphilitic *Roseola* consists of blotches of a reddish-brown or coppery tint, becoming more distinct as the redness declines; they vary in size from small circular spots to large and diffused patches, and are usually first observed about the abdomen. Syphilitic roseola is the most constant, and the earliest of all the syphilitic eruptions, often appearing before the primary sore is healed. It usually appears about seven or eight weeks after infection, and may last from a few days to two or three weeks. It is very frequently accompanied by an erythematous redness of the throat.

The *Squamous* syphilide, or, as it is often called, *syphilitic psoriasis*, occurs in small patches of an irregular shape, of a dusky red colour, sometimes assuming a coppery tint, covered with thin filmy scales. In many instances the patches are, however, quite smooth, so as to have a glazed and almost shining look. They are usually situated on the inside of the arms and thigh, often on the scrotum and penis, even occurring on the glans. They also frequently appear on the palms and soles, where deep fissures and cracks are met with. In moist parts, as in the folds of the groin in fat people, at the margin of the anus or between the toes, they become more elevated and merge gradually into the "mucous tubercle" or flat condyloma to be described hereafter. About the lips the squamous syphilide gives rise to deep and troublesome fissures. It differs from simple psoriasis in its showing a preference for the softer and moister parts of the skin, whereas the simple affection is most abundant on the drier parts, as on the back of the elbow or the front of the knee. The scales also are less abundant. Squamous syphilide forms the most common eruption, after the roseola, during the first year of syphilis. It is often associated with ulceration of the tonsils and iritis and not uncommonly with periostitis.

Papular Syphilide, or *Syphilitic lichen*, consists of small hard elevations, at first red, but afterwards becoming dusky or brownish. There is some slight brawny desquamation on the surface. They are most common on the forehead and shoulders, and last about three weeks before fading.

The *Vesicular* syphilide is of very rare occurrence. The vesicles vary in size from a pin's head to a pea. They soon dry, and when the scales so formed separate a coppery red patch is left beneath. In one case which fell under my observation, the rash appeared in the form of clusters of small pointed vesicles, which on drying left grey or brownish crusts and coppery marks. Many varieties have been described and named according to the non-syphilitic skin affections they resemble, as eczematous, herpetiform, varioliform, and varicelliform.

Pustular syphilides occur somewhat rarely in the early stages, but are more common later on. The early pustular syphilide commences as a small vesicle which early becomes pustular. It soon dries into a crust, which falls off, leaving an elevated coppery spot beneath. It is merely an aggravation of the vesicular eruption and leaves no ulceration or scar behind it. Larger pustules

forming slowly with a dusky-red or coppery areola are met with in cachectic subjects, forming the eruption known as *syphilitic ecthyma*. The pustules dry, leaving a dark flat scab, which after a time falls off, leaving an ulcer which heals slowly. Ecthyma is most common on the limbs.

In the late secondary or in the tertiary stage in debilitated subjects, the affection known as *rupia* is not uncommon. It seldom occurs before the end of the first year, and may be met with as long as the syphilitic taint persists. Rupia commences as a bleb which rapidly becomes converted into a large pustule, surrounded by a wide brown, or coppery areola. It soon dries into a circular dark brown, or even black scab. Beneath this ulceration takes place, and the crust increases in thickness from the drying of the discharge, while at the same time it extends at its circumference ; it thus comes to assume a conical form, and somewhat resembles a limpet-shell in appearance. After its separation a troublesome ulcer of a circular shape, often with a somewhat foul surface, is left, which may continue to spread slowly. This disease may appear on the face, but is especially common on the extremities. It is always indicative of grave constitutional debility.

Syphilitic *Tubercles* commonly occur as an advanced or tertiary symptom ; they are in fact gummata of the cutis vera. They appear as hard, smooth, flat elevations of a reddish-brown or purplish colour, usually arranged in groups of single tubercles lying closely together. They are seated on the face or extremities, the skin covering the patella and the ala of the nose being common situations. They may be resolved by proper treatment, but have a great tendency to ulcerate and to be followed by foul slowly spreading serpiginous sores. The ulcerating syphilitic tubercle forms the affection known as *syphilitic lupus*.

Subcutaneous syphilitic gummata, or, as they have been called, deep syphilitic tubercles, arise in the tertiary stage of syphilis as hard indolent masses in the subcutaneous tissue, usually accompanied by some slight aching pain or tenderness. They may vary in size from a pea to a walnut. They are of slow growth, but ultimately become adherent to the skin, which then assumes a dusky purple tint. If unrelieved by treatment the gumma softens and the skin gives way over it, exposing the characteristic adherent slough resembling wet washleather. This slowly separates, leaving a deep cavity. Subcutaneous gummata may occur at any part of the body ; common situations are the back of the thigh and the upper part of the arm.

Syphilitic *Boils* of an indolent character, but painful, and discharging a thin ichorous pus, with a core of shreddy areolar tissue, and leaving deep, irregular, and foul ulcers, are not uncommonly met with.

Syphilitic *Ulcers* are superficial and deep. The superficial ulcers arise from pustules, ecthyma, rupia, superficial tubercles, or boils. In other cases, especially on the leg, they arise like simple ulcers from some slight injury, but assume peculiar features in consequence of the syphilitic taint. Syphilitic ulcers are usually characterized by their multiplicity, by their appearing in parts not exposed to injury, as on the back or upper part of the leg, by their tendency to spread at one edge while healing at the other, and thus to assume a crescentic or serpiginous form, and by their unhealthy grey surface. They leave bluish or brownish cicatrices, often thin and smooth, and apt to break open again on any slight irritation.

The *Hair* during the first year of syphilis often becomes lustreless and dull,

and comes out in large quantities, often so as to cause baldness—syphilitic alopecia. Occasionally it may separate in patches. The baldness is not permanent, in fact it resembles the fall of the hair so often noticed in erysipelas and various fevers.

Diseases of the *Nails* are common. During the early stages the nails frequently become brittle and irregular in growth. A more serious affection is *Syphilitic Onychia*, which consists in a chronic inflammation of the matrix, with fetid discharge from under the nail; the end of the affected digit is swollen, purple in colour, and intensely tender, the nail becomes black, more or less bent, and scales off, leaving a dirty ulcerated surface exposed beneath. One nail only is usually affected.

Ulceration between the Toes with excessively foul discharge and much swelling of the foot is not an uncommon condition in syphilis. It apparently arises from the formation of soft flat growths of the same character as the mucous tubercles at the anus, the ulceration being due to the irritating secretion between the toes and want of cleanliness. It is easily recognized, for it may be taken as a rule that all ulcerations between the toes are due either to syphilis or scabies. The ordinary soft corn discharges no pus.

The *Treatment of Syphilitic affections of the Skin* must be conducted in accordance with the general principles already laid down. All the symmetrical eruptions occurring in the early stages of the disease are best treated by the administration of mercury according to the rules already laid down. The tubercular eruptions and the squamous ulcer, when occurring after the first year can often be relieved by iodide of potassium, especially if the patient has been treated with mercury in the earlier period. Donovan's solution is often of the greatest possible value, the disease rapidly disappearing under its use. The same plan is required in the management of syphilitic boils. In the pustular forms, syphilitic rupia and ecthyma, as the constitution is commonly shattered, a tonic plan of treatment is required in the first instance; after which the perchloride of mercury with tincture and decoction of cinchona, or decoction of sarsaparilla should be steadily administered. In these cases also much benefit will be derived from mercurial fumigation.

In most cases no *local treatment* is required for the squamous or papular eruptions, but should they occur in the face the patient is often anxious to hasten their disappearance. For this purpose dilute white precipitate ointment, or calomel made into a cream with olive-oil and lard, may be applied. Marshall recommends the application of a 10 per cent. solution of oleate of mercury with some morphia added. In all *ulcerating syphilides* iodoform, either applied pure or made into an ointment with vaseline, will be found most useful. In deep ulcerations iodide of starch ointment often produces a good effect. If these fail, yellow wash or perchloride of mercury in the strength of two grains to the ounce, diluted with water if it cause too much pain, will often arrest the spread of the ulceration and hasten its healing. If nothing else succeeds it may be necessary to cauterize the surface with fuming nitric acid or the acid nitrate of mercury. In syphilitic *alopecia* the internal administration of mercury has most influence in arresting the loss of hair; at the same time a stimulating lotion may be applied. B. Hill recommends the following ℞. :—Tinct. Cantharides, Solution of Ammonia, āā ℥ss.; Spirit of Rosemary, ℥i ; Glycerine, ℥ss. ; Rose water to ℥viij. In *syphilitic onychia* the nail should be removed and iodoform applied. Black wash or yellow wash

is sometimes useful. In *ulcerations between the toes* dilute white precipitate ointment, with a small quantity of extract of belladonna added, is the best application.

2. **Mucous Tubercles and Condylomata.**—Mucous tubercles are flat patches, seldom more than half an inch in diameter, slightly elevated, soft, and papillary on the surface. They are situated in moist parts of the body, very commonly on muco-cutaneous surfaces, as the anus, labia, and angles of the mouth ; they are also frequently met with on mucous surfaces, as on the tongue, tonsils, palate, and larynx, and exactly similar growths are found in any part of the skin that is kept moist by the natural secretions, and not properly cleaned, as between the scrotum and the thigh, in the fold of the groin in fat people, and between the toes. They are moistened by a good deal of mucous secretion when seated on mucous membranes, or by perspiration when on the skin. In the mouth and throat they are usually small and not so distinctly elevated, but rather like a thickened and opaque condition of the mucous membrane in these situations. At the anus they sometimes attain a considerable size, so as to project a quarter to half an inch above the surface, and it is then that they are commonly termed condylomata. They are frequently mistaken by the patient for piles. They consist essentially of an overgrowth of the papillæ stimulated in part by the irritation of dirt or unhealthy secretions. They are common in conjunction with the squamous syphilide on the dryer parts of the skin, and every gradation can sometimes be traced between a scaly patch to a mucous tubercle, according to the moisture of the part in which the patch is situated. They are met with most commonly during the first six months of the disease. They differ from the venereal warts already described (p. 1079), not only in their flatter form and less marked papillary structure, but in being dependent on a constitutional disease, and not on local causes solely, such as the irritation of discharges and want of cleanliness. The discharge with which they are moistened is intensely contagious, and it is from them, when situated in the mouth, that the disease is transmitted by kissing, or by means of drinking-vessels, or pipes, and from infants to their nurses.

Their *Treatment* must be constitutional and local. The constitutional treatment is merely that of early syphilis. Locally they are best treated by the application of white precipitate ointment when seated at the anus or on the skin. If this does not relieve them they may be rubbed with nitrate of silver or sulphate of copper. In the mouth the application of a solution of perchloride of mercury (gr. ij to ℥i), or of the solid nitrate of silver, is the best treatment. Not being pendulous, they do not, like simple venereal warts, require to be cut off.

3. The **mucous membranes** of the *mouth, pharynx, and larynx* are commonly affected with secondary syphilitic eruptions, which assume the form of mucous tubercles, and of the exanthematous, squamous, and ulcerating syphilides ; and in the later stages of the disease submucous gummata may form.

The *exanthematous* affection, corresponding to the roseolar form of cutaneous syphilis, and arising from the same cause and in the same constitution, principally affects the palate and throat. The *tubercular* variety corresponds to the squamous cutaneous eruptions, and is met with chiefly as flat, hard, and elevated tubercles in the interior of the mouth, nose, and throat. The

ulcerative affection of the mucous membranes assumes a variety of forms, which will immediately be described, and occurs principally in the throat and nose. The exanthematous affection of the mucous membrane is usually an early sign of constitutional syphilis, frequently showing itself a few weeks after the primary occurrence of the disease. The other varieties belong to the more advanced secondary or tertiary periods. *Contractions* of various mucous canals often occur as the result of syphilitic affections, the narrowing being due to firm, fibrous bands, often excessively dense in structure. These are often merely cicatricial, formed on the healing of syphilitic ulcerations. In other cases they seem out of all proportion to the extent of the destruction by ulceration, and would appear then to be due to diffuse fibroid induration of the submucous tissue, followed by contraction. They are most frequently met with in the rectum, vagina, and pharynx.

The syphilitic affections of the mucous membranes are most conveniently considered according as they affect distinct organs or parts of the body.

The *Lips* are commonly affected in persons labouring under squamous syphilide, with fissures or cracks usually somewhat indurated, and very painful in the movement of these parts. In the *Treatment*, the application of a pointed piece of nitrate of silver to the bottom of the crack will give the most effectual relief. The insides of the cheeks are not unfrequently affected in a similar manner, or become the seat of mucous tubercles, which must be treated as has already been stated.

The *Tongue* may be affected in various ways: when severely, its disease usually constitutes one of the tertiary manifestations of syphilis.

In the early period of the secondary stage of syphilis, small papules, similar to those on the skin may appear. They are of little importance, and cause no inconvenience. During the second half of the first year of syphilis, and often at a later period, small superficial ulcers on the sides of the tongue, having an irregular or oval outline, and a gray surface, are not uncommon. They cause considerable discomfort. They are best treated by being touched twice a day with a solution of perchloride of mercury (gr. ij to ℥j). The surface must be previously dried with a handkerchief. Solid nitrate of silver is often as efficacious. Another form of late secondary manifestation on the tongue is a small fissure, or crack, at one side, surrounded by a zone of thickened epithelium, which gives the mucous membrane at the affected spot an opaque blue tint. These ulcers require the same treatment as those just described. Mucous tubercles are not uncommon on the tongue, but are less frequent than on the lips or cheek.

At a later period the dorsal surface of the tongue, usually only in its anterior half, undergoes a chronic change. The epithelium becomes opaque, white, and thickened, sometimes in patches, sometimes uniformly, and if the tongue be dried and then examined, it will be observed that the papillæ in the affected area have disappeared, the surface being almost smooth. The disease is a chronic inflammation affecting the corium of the mucous membrane, and the submucous tissue, with overgrowth of the epithelium covering the affected part. It has received various names, according to the appearance produced: when the surface is smooth, and bluish in tint, it is spoken of as the "*smooth tongue*," or *chronic superficial glossitis;* when the opacity is greater it has been called *psoriasis of the tongue;* and when the epithelium is heaped up so as to form scales, the term *icthyosis linguæ* has been

applied to it. These conditions most frequently result from syphilis, but cases are often met with in which no history of the disease can be obtained; they are permanent, the normal papillary condition of the tongue never being regained. Simple ulceration is not uncommon in the opaque patches, and in later life epithelioma frequently attacks the diseased mucous membrane. The treatment of this condition is very unsatisfactory. Perchloride of mercury lotions are often of use. Internally iodide of potassium produces most effect. If it fails, and the patient is in a state to stand it, a course of mercury may be tried.

The tongue is affected also in some cases by *diffuse overgrowth of its connective tissue*, occurring in patches and extending deeply into its substance from the mucous surface. More commonly it is the seat of *gummata*. These form, as a rule, in the muscular substance of the organ, and sometimes in the fibrous septum. They form indolent tumours, gradually reaching the mucous membrane, and implicating it. They run the usual course of gummata, and when they soften and open on the surface, leave deep, foul ulcers, which may be mistaken for epithelial cancer. The diagnosis of these affections, and their treatment, will be more fully considered under the diseases of the tongue.

The syphilitic diseases of the *Throat* are amongst the most common manifestations of constitutional syphilis, and frequently occur early. They present three chief forms, occurring in the early secondary, the later secondary, and the tertiary stages of the disease.

The early secondary eruption is a deep-red exanthematous efflorescence of the soft palate and pillars of the fauces, either without ulceration or with but superficial abrasion. It occurs about the period of the invasion of the roseola and requires no special treatment. In the later secondary period, corresponding to that at which the squamous and papular eruptions appear on the skin, ulceration of the tonsils is very common. It appears first as white patches and mucous tubercles, in the centre of which the ulceration commences. The ulcers have sharply cut edges, often somewhat undermined. Superficial mucous patches may surround the ulcer, and extend on to the soft palate and pillars of the fauces. These ulcerations give little or no pain in most cases, and never cause any serious destruction of the mucous membrane. They require the ordinary treatment of constitutional syphilis, and locally may be occasionally touched with the perchloride of mercury solution (gr. ij to ℥j), or with nitrate of silver.

The tertiary ulcerations of the pharynx are far more serious. They seldom occur till three or more years after infection, and then only in patients in a debilitated state of health. The ulcers commence by a gummatous infiltration of the mucous membrane, similar in character to the tubercular syphilides of the skin. This breaks down, and a serpiginous ulceration starts from the affected spot, and may spread widely and rapidly. The ulcer has an irregular form and a foul gray surface, and may destroy in a few weeks a great part of the pillars of the fauces or of the soft palate. When the soft palate is destroyed, there is usually considerable difficulty in deglutition, and speech becomes altered. This form of ulceration occurs sometimes simultaneously with rupia on the skin, and requires the same constitutional treatment. The best local application is a gargle, composed of corrosive sublimate, gr. iv; hydrochloric acid, ♏viij; and water, ℥x. If the patient cannot gargle, or

if the treatment has no effect, corrosive sublimate lotion (gr. ij to ℥j) may be carefully applied with a camel's hair pencil. Dusting the surface with iodoform often produces a most excellent effect. It may be used in conjunction with the perchloride lotion or gargle. It is important to remember that gargle of the perchloride of mercury cannot be safely used of a greater strength than a quarter to half a grain to the ounce of water; stronger preparations must be applied with a brush.

When the ulcers heal the contraction of the cicatrices may give rise to *stenosis of the pharynx.* This may occur in three situations. 1st, between the top of the palate and posterior wall of the pharynx, so as to cut off the nasal cavities; 2nd, between the soft palate, the walls of the pharynx and tongue, and 3rd, across between pharynx and posterior wall of larynx.

This stenosis is probably the result of ulceration of the opposite mucous surfaces; but it is often out of all proportion to the extent of the ulceration.

The stenosis may gradually increase until the contraction becomes so great that deglutition becomes seriously impeded and respiration is carried on with great difficulty.

In the second and third forms of the contraction it becomes necessary, in order to enable the patient to swallow and to breathe, to dilate the opening. This, if it be not too tight, may be done by simple dilatation by means of bougies. If very contracted, its edges should be carefully notched before dilatation. Before doing this it may be well to have recourse to Tracheotomy as a prophylactic measure, averting all danger of suffocation and spasmodic irritation during the manipulations in the pharynx.

Syphilitic ulcerations have been described as occurring also in the *œsophagus* and leading to stricture of that canal.

The mucous membrane of the *larynx* is not unfrequently affected both in early and in advanced syphilis. The affections are similar to those of the fauces and pharynx. During the early exanthematous eruptions there may be some catarrh with hoarseness and slight cough. Later on flat mucous tubercles may appear, but ulceration is rare. They disappear under treatment, leaving no ill effects behind. In the tertiary stage the most extensive ulceration, leading to destruction of the epiglottis and vocal cords, with necrosis of the cartilages may take place. There is usually great thickening of the arytæno-epiglottidean folds, not unfrequently complicated by the formation of submucous gummata. If the patient recover the opening of the glottis may be so far closed as to necessitate tracheotomy, and the constant use of a tube for the remainder of life. The symptoms and treatment are more fully described with Diseases of the Larynx, Vol. II.

The *Nose* is commonly affected in constitutional syphilis, and often destructively so, especially in individuals much exposed to changes of temperature, and who are unable to pay proper attention to their treatment. The mucous membrane becomes chronically thickened, and this is accompanied by discharge of blood and pus, coryza, and habitual snuffling. In other cases ulceration takes place, with a very fetid odour of the breath, and the formation of thick ecthymatous crusts on the septum, or between this and the alæ. This ulceration is very persistent and troublesome, and requires usually a mercurial treatment, with the local application of strong nitric acid, or of the acid nitrate of mercury, to arrest its progress. In many cases ulceration will rapidly proceed to destruction and perforation of the septum, or necrosis of the spongy

bones, the vomer, and ethmoid; sometimes excavating the whole of the interior of the nose, scooping and cleaning it out into one vast chasm. When this happens, the nasal bones also are usually flattened, broken down, and destroyed; the alæ and columna ulcerating away, and producing vast disfigurement. In other cases the hard palate is affected, and perforation takes place from the nose into the mouth. Occasionally the disease extends to the bones of the base of the skull, and in this way may occasion impairment of vision, epilepsy, or death. Cerebral symptoms, however, do not necessarily occur when the base of the skull is implicated. In 1870 I removed the whole body of the sphenoid from the nasal cavity of a man who had never suffered at any time from any disturbance of the cerebral functions.

The *Treatment* of these nasal affections must be conducted in accordance with general principles. In many cases mercurial fumigation is extremely useful, though as a rule iodide of potassium has more effect. Iodoform sniffed up the nose, either pure, diluted with nitrate of bismuth, or starch powder, is more efficient than any other application in destroying the intolerable stench that proceeds from syphilitic disease of the bones of the nose. The cavity must also be washed out twice a day by means of a nasal douche. When loose the dead bone must be removed. (See Diseases of the Nose, Vol. II.)

The mucous membrane of the *rectum* is frequently affected in syphilis. In the early stages of the disease mucous tubercles are common at the anus. Small superficial ulcers, similar to those on other mucous membranes, may also be met with. These are, however, not of serious importance. The tertiary affections of the rectum, on the other hand, are always serious and often fatal. They occur most frequently in women. Two conditions are usually met with together—fibroid induration of the coats of the gut and ulceration of the mucous membrane. Submucous gummata are very rare. The induration of the coats of the gut, as a rule, precedes the ulceration; it commences by a growth of imperfectly developed fibroid tissues in the submucous tissue, starting from the region of the anus and extending upwards. The new tissue, as it develops, contracts like that of a scar, and thus the wall of the gut becomes indurated and the canal narrowed. In the later stages the fibroid growth extends into the muscular coat, and the peritoneal covering may be thickened and opaque. The thickening of the submucous tissue interferes with the proper vascular supply of the mucous membrane, and ulceration follows. The ulcers have a foul gray floor and slightly raised edges. They may slowly perforate the gut into the vagina or peritoneum; but general peritonitis is rare, as from the slowness of the process firm adhesions to surrounding parts have usually formed before perforation takes place. (See Syphilitic Stricture of the Rectum, Vol. II.) As the induration of the coats of the gut at first causes but little inconvenience, these cases seldom come under the care of the Surgeon till some ulceration has taken place. In some cases serpiginous ulceration may be the primary change; but these are certainly the less common.

4. **Syphilitic Iritis** usually occurs during the first year after infection, and often in people who are otherwise strong and healthy. The ordinary symptoms of iritis, somewhat modified, characterize the affection. The patient complains of dimness of sight, pain in the eye, and often of very severe circumorbital or hemicranial pains. On examining the eye, the conjunctiva will be found to be slightly injected, and a zone of pink vessels to be seated

on the sclerotic, close to the cornea ; the aqueous humour has lost its transparency, giving a muddy look to the eye, and the colour of the iris is altered. The pupil is diminished in size and irregular in shape, usually angular towards the nasal side, and small yellowish or brownish nodules of lymph may be seen to be deposited on the surface of the iris. If the case be left to itself, or be improperly treated, it will advance to disorganization of the globe, and to permanent loss of sight. The retina often becomes affected, and incurable blindness results.

The *Treatment* consists in local depletion by means of cupping and leeches to the temples, and the administration of calomel and opium internally, at the same time that a strong solution of atropine is put frequently into the eye. Most commonly, as the mouth becomes affected by the mercurial, the eye will clear, the lymph becoming absorbed, and the pupil regaining its normal shape and colour. In some cases, however, a chronic inflammation continues ; here the best effects result from the administration of small doses of perchloride of mercury, with repeated blistering to the temples ; and, in a later stage, soda and bark may be advantageously given.

5. **Syphilitic Diseases of the Bones.**—The bones are liable to suffer both the secondary and tertiary stages of syphilis.

In the secondary stage aching pains in the bones are not uncommon. They are worse at night, and may be unaccompanied by any recognizable change of structure.

The characteristic bone diseases of syphilis are usually delayed till the tertiary stage, some two years or more after infection. By some Surgeons the graver forms are said to be the result of the administration of mercury, rather than of the syphilis for which the mineral is given. This doctrine I believe to be entirely without foundation. That they are met with in syphilitic cases in which no mercury has been given, there can be no doubt. I have had under my care patients with extensive disease of the cranium and of the clavicle, whose syphilis had been treated from first to last on the non-mercurial plan. One patient, especially, a soldier, from whom I removed portions of the cranium and of the clavicle for necrosis accompanying constitutional syphilis, had been treated in a military hospital without mercury. I have never seen or heard of mercury producing necrosis in any bones, except those of the jaws, when given for diseases other than syphilis. No doubt diseases of the bones are especially apt to occur when the patient's constitution has been broken down by any means ; and an improperly conducted mercurial course may have this result. They occur usually after the patient has passed through the whole course of the less severe syphilitic affections, such as those of the skin, mucous membrane, and throat. The affections of the bones, however, may in some cases declare themselves at the same time with the affections of the skin and mucous membranes. They more commonly occur amongst the poorer classes, especially those who are exposed to atmospheric vicissitudes, and chiefly in strumous constitutions.

The diseases to which the bones are liable as a consequence of syphilis are the following :—

Syphilitic Periostitis or Node.—This consists of a localized inflammation of the periosteum, usually affecting one bone only, but sometimes many. The inflammation is accompanied by exudation into and under the membrane ; the exudation may be absorbed, and the part restored to its normal condition,

but more commonly it is partly or entirely developed into new bone, and thus a permanent thickening may remain. In the early stages the new bone is soft and spongy, and is sharply separated from the compact bone beneath, which beyond some slight superficial rarefaction from enlargement of the Haversian canals shows no sign of change. As time goes on, however, the new bone becomes more compact till at last it seems merely a part of the compact tissues which may at the affected spot be a little denser than natural. Nodes may occur on almost any of the bones; but they are most commonly met with on the tibia, the clavicle, or the bones of the forearm. They form indolent, elongated, uniform, elastic or hard swellings, usually tender on pressure, and generally but little painful during the day; but at night the aggravation of pain is peculiarly marked, and constitutes perhaps the most distressing symptom. They cause no redness of the skin and have no tendency to suppurate.

Sclerosis of Bone.—This corresponds to the diffuse overgrowth of fibroid tissue in other parts. It usually affects one of the long bones of the cranium. The affected bone becomes increased in size and density. The new osseous tissue is formed on the surface from the periosteum, but does not show the distinct separation from the old so clearly noticed in the ordinary node, the growth is, moreover, not limited as in a node, but widely diffused as through the whole shaft of a long bone or throughout the vault of the skull. At the same time that new bone is formed on the surface a similar change may occur internally till the medullary canal becomes gradually filled with dense new bone. The symptoms of this affection are merely the steady increase in size, with obscure aching pains, worse at night.

Gummata of Bone.—These never form as the sole morbid condition; they are always associated with the periosteal node or with sclerosis of the surrounding bone. They most commonly form superficially, and are at first indistinguishable from the ordinary node; in fact, as before pointed out, the gumma in its commencement is identical in its nature with the diffuse syphilitic overgrowth of fibroid tissue, differing merely in its localization and intensity and in its tendency to fatty degeneration and softening. A subperiosteal gumma runs the ordinary course of such growths; if unrelieved by treatment it gradually increases in size, approaches the skin superficially, and extends into the bone beneath; finally, it softens, the skin gives way, the slough is discharged, and a deep ulcer is left, at the bottom of which spongy ulcerating bone is exposed. This forms the most common variety of *syphilitic caries.* In the cranium the gumma may completely perforate the bones, but more commonly it is associated with great sclerosis of the vault of the skull, the thickened bone being hollowed out and wormeaten in parts corresponding to the situation of the gummata. Occasionally the gummata form on the internal aspect of the skull, and may give rise to cerebral symptoms. Gummata of bone form rounded flattened tumours, growing from the bone slowly, with some aching pain, usually worse at night. After a time they soften, and may then resemble abscesses. However soft the part may be, they must on no account be opened; as absorption may take place even after distinct fluctuation is present.

Syphilitic Necrosis may arise in various ways. In the vault of the skull it is most commonly due to an exaggeration of the process of sclerosis, by which the Haversian canals become obliterated to such an extent that death of the

bone follows. The sequestra thus formed are often of considerable size, sometimes reaching that of the palm of the hand. They are composed of dense hard bone, much thicker than the normal skull, and always more or less wormeaten on the surface. This appearance is due to the previous existence of subperiosteal gummata which have softened and been thrown off. The skin of the scalp having been implicated in the gummata is destroyed partly by the softening of the gummata and partly by subsequent ulceration, so that the surface of the sequestrum is usually bare and exposed. The process of separation is very slow, often lasting many years. Cerebral symptoms may be present, but are certainly quite as often absent. Necrosis of the bones of the base of the skull may arise in the same way, or may result from ulceration of the mucous membrane of the nasal cavity or pharynx by which they are in many parts thinly covered. The tertiary ulcerations in the mouth and nose also may be followed by necrosis of the hard palate, of the turbinate and ethmoid bones; but it is a remarkable fact that the hard palate is not nearly so frequently affected as the nasal and spongy bones. In consequence of this destruction of bony tissue, the nose may fall in, or a communication may be established between the nose and mouth through the hard palate. Syphilitic necrosis may affect also the alveolar processes of the jaws. It is very uncommon in the long bones.

Syphilitic Caries, or ulceration of bone, is most commonly the result of the softening of a periosteal gumma, but it may be due to the extension of a superficial ulcer to the bone in thinly covered parts. The caries is rarely uncomplicated; usually, the surrounding compact bone is sclerosed, or in the neighbourhood of the ulcer there may be a considerable formation of new bone from the periosteum. In other cases the process is a combination of necrosis and ulceration; the sequestra being surrounded by a zone of ulceration extending a considerable distance from the dead bone and not closely limited to its edge, as in the process of separation of a simple piece of dead bone. Syphilitic caries is most common in the skull, but it is met with also in other parts. The upper part of the sternum is not an uncommon situation. It is also met with in the extremities. I have twice seen a peculiar form of caries of the cancellous tissue of the head of the tibia in old syphilitic cases. In both cases, which were very similar, the patients had been affected for a length of time with nodes of the tibia, as a consequence of long antecedent syphilitic taint. A chronic abscess eventually developed over the head of the bone, leading to a carious cavity. I exposed this and gouged the diseased bone away; it was peculiarly dry, light, and almost flocculent, if such a term can be applied to bone. Both patients recovered well from the operation; but one of them, a female, died two years afterwards of epilepsy, consequent on syphilitic gummata of the dura mater.

Both in acquired and hereditary syphilis the bones of the fingers and toes are sometimes attacked, giving rise to the condition known as *syphilitic dactylitis*. It most commonly assumes the form of gummatous periostitis, often followed by softening of the new tissue and necrosis of the phalanx. The affected bones are much enlarged.

From the foregoing description it will be seen that the diseases of bones due to syphilis are all modifications of the same process which characterizes the disease elsewhere in its tertiary stage, namely, an overgrowth of the connective tissue, the new tissue accumulating in some places in such masses as

to form a distinct tumour, the gumma, which being imperfectly supplied with blood tends to degenerate. The node and the uncomplicated sclerosis of bone form the simplest stage of the process, the formation of gummata is the next advance, necrosis is an accident due to exaggeration of the sclerosis, or to exposure of the bone from softening of the gummata, and caries results also from the latter condition. It is not surprising, therefore, that we meet with these various effects combined in every possible way ; the gumma is always surrounded by periostitis with or without the formation of new bone, caries and necrosis occur mixed together, and new growth and destruction may go on side by side.

The *Constitutional Treatment* of syphilitic diseases of the bones is that already recommended for the tertiary stage of the disease. Mercury is admissible only if the patient is otherwise in good health. Usually the iodides of potassium or sodium give the desired relief when administered in sufficiently large doses. *Locally* the treatment varies with the form assumed by the disease. The simple node usually requires no local treatment. If it is very chronic and painful, blisters will almost always give relief. If these fail and the case proves very intractable, and especially if there is considerable formation of new bone, I have found the greatest advantage result from cutting down upon the enlarged, thickened, and tender bone, and by means of a Hey's saw making a deep cut into it about one and a half or two inches in length parallel to its axis, and down to the medullary canal. By this operation the tension is at once relieved, and the pain effectually and permanently removed. In syphilitic *necrosis* the necrosed bone should be separated as it becomes loose, the local irritation depending on its presence then subsiding. When the bone has fallen into a *carious* state, the unhealthy surface should be thoroughly scraped with a sharp spoon, and the cavity dressed with iodoform or iodide of starch ointment.

Syphilitic diseases of **Joints** are not of frequent occurrence. Pains in the joints are not uncommon during the very earliest stages, before the appearance of the eruptions ; and during the secondary stage some slight synovitis has occasionally been observed, apparently due to the disease, but these conditions are of no great importance. In the later stages the joints may become affected by the formation of gummata in the capsule or in surrounding structures, but this is not common. The articular ends of the bones are less liable than other parts to syphilitic disease in the adult.

7. Syphilitic disease of the **Muscles** and **Tendons** has been described by Bouisson and others. These structures are not unfrequently affected, but less often than the bones. In the muscles diffuse sclerosis has been described, but it is exceedingly rare. Gummata are much more common ; they form ill-defined tumours in the substance of the muscle, growing slowly, with some aching pain and tenderness. They are less prone to soften than similar growths in more superficial structures. Elongated tumours resembling nodes have been described as affecting the tendons, and gummata are occasionally observed in their substance. They resemble similar growths elsewhere, and are best treated by iodide of potassium.

8. **Syphilitic disease of the Testicle.**—This assumes two forms—the diffuse overgrowth of the inter-tubular connective tissue, and the formation of gummata. These diseases affect the body of the gland, and are always met with as tertiary phenomena. The symptoms, pathological

appearances, and treatment, are fully described with diseases of the testicle, Vol. II.

9. **Syphilitic Ovaritis** is a disease that I believe I have on several occasions met with. The history of the cases has been uniformly as follows: an attack of syphilis long ago; various constitutional symptoms running through secondary and tertiary stages; inflammatory congestion of one ovary, as determined by vaginal and rectal exploration; eventual cure by means of leeching and the perchloride of mercury and bark or iodide of potassium;—in fact, a condition of things closely resembling what occurs in syphilitic disease of the testicle.

10. **Visceral Syphilis.**—Our knowledge of the syphilitic diseases of internal organs is of modern origin, and still somewhat imperfect. "Visceral Syphilis" was not only unknown to, but unsuspected by, so acute an observer as John Hunter, and the syphilographers of the early part of this century make no mention of it. To Dittrich, Lancereaux, Wilks, Bristowe, and Moxon we are indebted for the establishment of the fact that, after external manifestations of syphilis have in a great measure, if not entirely, disappeared, and the disease has entered its tertiary stage, gummata may form in most, if not in all, the internal organs, producing serious functional disturbance, and leading to organic changes of the most extensive, deep-seated, and fatal character.

It may now be taken as a fact, incontestably established by numerous pathological observations, that there are few, if any, organs that escape the ravages of syphilis; and although there may be a doubt whether some of the forms of disease met with in certain organs, as the liver, lungs, and spleen, and described as syphilitic, may not in reality be due to non-specific disease, to which, as well as to syphilis, they are common, there can be no doubt of the fact, as Moxon has pointed out, that when gummata are met with in internal organs, the fact of the syphilitic nature of the disease is established.

The general pathological characters of the changes in the viscera and in the arteries have already been described (p. 1092). The complete description of the visceral affections belongs rather to Medicine than Surgery, and it will be sufficient here briefly to indicate their nature.

In the *heart*, syphilitic deposits have been found on the endocardium, less frequently in the valves; and two forms of myo-carditis of syphilitic origin—one circumscribed, the other diffuse—have been described by Lancereaux.

The *lungs*, *liver*, and *spleen* are all liable to syphilitic deposits. As a general rule, they may affect two forms—occurring either as gummata or as a diffuse interstitial growth, which in the liver may simulate cirrhosis, and in the lungs some of the forms of "fibroid phthisis." These syphilitic visceral diseases not unfrequently run a fatal course: rarely, however, destroying the patient before the age of 35 (Wilks). The diagnosis of the specific nature of the affection must always be open to doubt, except in those cases in which the history of the infection has been continuous, and some of the more superficial and easily recognizable syphilitic affections are associated with the visceral forms of the disease. So far as treatment is concerned, our chief reliance must be placed on iodide of potassium, or if that fail, on the careful administration of mercury.

11. Syphilitic disease of the **Mamma** is of extreme rarity, and little is definitely known about it. Gummata have been described by Hennig as having been observed after death in one case.

12. There is no more distressing form of syphilitic disease than that which

affects the **Nervous System.** The brain and spinal cord and their meninges, and the trunks of the nerves, are all liable to suffer.

Syphilitic affections of the nervous system have been described as occurring during the first year after infection, but such cases are of extreme rarity; as a rule they do not manifest themselves till after the end of the second year, and they may appear as late as the tenth, or, it is said, even the twentieth. They occur at all ages, and are not uncommon in young men. I have often seen syphilitic disease of the nervous system about the age of 25 or 30. It is the common cause of paralysis in early manhood. The development of the symptoms may follow some slight accident—a fall upon or a strain of the back, or over-exertion in walking, riding, or running. The primary disease has often been slight—the secondary symptoms trivial; and indeed no great importance may have been attached to the venereal infection until the manifestations of its most terrible and destructive effects on the brain and cord. In other cases the patient may be suffering, at the time of the appearance of the nervous symptoms, from severe tertiary affections, such as ecthyma, rupia, serpiginous or sloughing ulceration of the throat, or painful nodes on the cranium, vertebral column, or long bones. Habitual excess in alcoholic stimulants forms a powerful predisposing cause of syphilitic disease of the nervous system.

The pathological changes in the nervous system are of the same character as in other parts of the body. They consist of chronic inflammation, with thickening of the meninges; overgrowth and induration of the interstitial tissue of the nervous centres and nerves; the formation of gummata; and the obstructive changes in the arteries already described (p. 1092). Certain chronic degenerative diseases of the cord, especially sclerosis of the posterior columns (locomotor ataxy), follow syphilis with sufficient frequency to justify the belief that the disease may stand in some causal relation to them.

Syphilitic disease of the brain declares itself by two chief symptoms, either separately or conjoined: viz., paralysis and epileptic convulsions. Before these definite signs manifest themselves, various premonitory symptoms may have existed. The most common is severe pain in the head, usually fixed in one spot, often worse at night; there may also be some mental disturbance and want of sleep.

Paralysis from syphilitic disease of the brain usually assumes the form of hemiplegia. It may be preceded by paresis of special parts, as of one limb or group of muscles, which may be temporary in its character. The nerves of sensation also may be affected. Special cranial nerves may suffer. The third, fourth, sixth, and seventh are often early attacked, giving rise to ptosis, strabismus, or facial palsy. I have never seen the fifth nerve paralysed in syphilis, but cases have been recorded in which it was affected. Oculo-motor paralysis in some form, on the other hand, is very frequently the result of syphilis, and when it occurs in young men it should, however passing and slight, always attract the most serious attention, as it is often the precursor of more general paralysis. The early affection of the nerves that lie in the wall of the cavernous sinus is probably due rather to syphilitic thickening of the dura mater, with which they are in such close relation, than to an affection of the substance of the brain.

If the patient be hemiplegic, he may be completely so, but very often the paralysis is limited to one limb, or may be irregular in its degree in different

parts. It is often accompanied by rigidity. These differences are due to the situation of the disease in the brain. Gummata in the dura mater or bone in the region of the cortical motor centres may cause irregular paresis or complete paralysis of the parts corresponding to the affected centre. Syphilitic growths in the deeper parts of the brain may give rise to complete hemiplegia, coming on gradually, and occlusion of a cerebral artery affected with the changes already described as occurring in syphilis, may lead to the same symptoms being developed suddenly. Aneurisms also of the cerebral arteries, ending in rupture with the ordinary signs of apoplexy, may occur as the consequence of syphilis.

Optic neuritis is very common in syphilitic disease of the brain, especially in cases of very chronic meningitis, or when gummata are present.

Epileptic seizures are common in syphilitic affections of the brain. They generally result from chronic thickening of the dura mater, or the development of gummata in the membranes or substance of the brain in the region of the cortical motor centres. Gowers states that they "differ from the ordinary convulsions of epilepsy, especially when the motor zone of the cortex is diseased, in the deliberate onset of at least some of the attacks; in consciousness being lost late, and in the patient being aware of the local onset of the convulsions in the face, hand, or foot. In other cases, probably when the sensory rather than the motor region is diseased, a sensory aura, often involving the special senses, may herald the fit." According to Gowers, syphilitic epilepsy is recognized by its appearing usually at an age when the idiopathic disease seldom commences, by the headache between the fits, by the coincidence of optic neuritis, and often of local paralytic symptoms, and by the early and often progressive mental disturbance. The fits are often of a very violent character, and followed by coma. But dangerous as these attacks may become, there is always a prospect of cure by proper treatment, although in some cases the fits may persist even after there is every reason to believe that the syphilitic growth which originated them has been absorbed. In other cases again, the mental powers undergo gradual deterioration, delusions manifesting themselves, and the patient falls into a state of semi-imbecility.

There is truly not a more pitiable object to be seen than a man, young or in the prime of life, suffering from syphilitic disease of the nervous centres—affected by ptosis, with one eye staring and immovable or squinting, the face distorted, the lip dropped and saliva dribbling, defective in his articulation, straddling and insecure in his walk, dragging one leg behind him, at times the victim of the most frightful epileptic paroxysms, often covered by rupial sores—he is truly a fit object for commiseration rather than one for reprobation and reproach.

Syphilitic disease of the Spinal Cord.—The most common syphilitic lesions of the cord are chronic meningitis and the development of gummata, which arise most frequently in the membranes, but sometimes originate in the substance of the cord itself. The gummata are usually small, rarely exceeding half an inch in diameter, though Wilks has recorded a case in which the tumour reached the size of a large filbert. Most commonly only one gumma is met with, but cases have been described in which numerous small tumours the size of millet-seeds were present. When the disease assumes the form of meningitis, there is usually considerable thickening of the dura mater, but the other membranes also may suffer, and the superficial parts of the cord be im-

plicated. The roots of the nerves are compressed as they pass through the thickened membranes. The disease may be widely diffused, but is more commonly limited in extent, the region of the lumbar enlargement being specially prone to be affected.

Syphilis may be the cause also of disseminated chronic myelitis, leading to sclerosis, and Gowers has brought forward a large amount of evidence to show that locomotor ataxy (sclerosis of the posterior columns) may have its origin in this way ; about one-half of the cases of this disease occur in patients who have suffered from constitutional syphilis.

The *Symptoms* of syphilitic disease of the cord supervene gradually. They are pain either in the back opposite the seat of disease, or referred to the parts supplied by the nerves arising from the affected portion of the cord. Various affections of sensation are commonly met with ; there may be numbness, tingling, or pins and needles, or local spots of hyperæsthesia or anæsthesia. Paralysis of one limb or a part of a limb, or complete paraplegia, may form a prominent symptom. Wasting occurs only in those muscles which are paralysed in consequence of damage to the part of the cord from which their nervous supply is derived, or of pressure on the roots of the nerves. Thus, although there may be complete paraplegia, the wasting may affect only certain groups of muscles. The reflex function of the cord is abolished in the diseased part, but lower down it may be increased ; thus in disease in the dorsal region there may be exaggerated reflex movements in the lower limbs. Rigidity of muscles is common, spasm comparatively rare. When the paralysis is unilateral, the modifications of sensation will be on the same side as those of motion when the roots of the nerves are affected, but on the opposite side when the condition is due to the growth of a localized tumour, either in the substance of the cord or in its membranes. The symptoms may be rendered very irregular and complex by the co-existence of various lesions, such as irregular patches of chronic meningitis, or a gumma combined with meningitis, or more than one gumma in different parts of the cord, and this irregularity of the symptoms may be still further increased by simultaneous disease of the brain and its membranes. The age of the patient, the history of syphilis, and the irregularity of the symptoms often render the diagnosis comparatively easy.

The *Nerves* are comparatively rarely affected, though gummata have been met with growing from the connective tissue forming their sheaths. These have been observed almost exclusively in the cranial nerves.

In the *Treatment* of syphilitic disease of the central nervous system, if not too far advanced, there is fortunately much to be done for the patient's relief, if not complete cure. Mercury in some form, more especially the perchloride with decoction of cinchona, if not previously fully used, should have a fair trial. Iodide of potassium in gradually increasing doses, up to fifteen or twenty grains, three times a day, if the patient can stand it, should be given at once in those cases in which the patient has already had a full course of mercury, or in which the constitutional state does not justify the administration of mercury at the time the nervous symptoms set in. Counter-irritation by means of blisters or setons will occasionally be found useful. The epileptic convulsions may be relieved by bromide of potassium or of ammonium, but these must not be given to the exclusion of the iodides. Under this treatment cases at first apparently hopeless may rapidly recover, but when the disease is

far advanced, with the formation of gummata of large size, the prognosis becomes very bad.

INFANTILE, CONGENITAL, OR INHERITED SYPHILIS.

Chancres on the labia of the mother may possibly infect the child at birth; just as they may inoculate the hand of the accoucheur ; but syphilis thus contracted by the infant is not the form of the disease that is described as **Infantile Syphilis**. This is a truly hereditary infection, transmitted to the infant at the time of its conception, or communicated to it through the medium of the mother during intra-uterine life, and existing as a constitutional affection at the time of its birth. Though we may believe that syphilis is not easily eradicated from a system into which it has once been received, and that under certain conditions it may readily be transmitted to the offspring ; yet I think that we are still ignorant of the amount and nature of the constitutional affection of the parents that are necessary for the development of syphilis in their children, and that we are certainly not warranted in concluding that a parent who has been, or even who is actually affected by constitutional syphilis, must necessarily have a syphilitic, or even a feeble and strumous family ; although the probability undoubtedly is that the offspring will be syphilitic. I have had under my observation a gentleman whom I had attended for secondary syphilis, and who, contrary to my advice, married some years ago ; and, though he has since then suffered from psoriasis of the hands, mucous tubercles, fissures on the lips and tongue, and syphilitic disease of the testicle, yet his wife has borne a perfectly healthy family, not only without any syphilitic taint, but without any apparent constitutional cachexy.

When the parents are syphilitic, the fœtus frequently fails to arrive at maturity. This may be due to disease of the placenta, or of the umbilical cord, or to the direct action of the syphilitic virus on the fœtus itself. In the placenta extravasations of blood, fatty degeneration, and the formation of caseous, and occasionally of calcareous masses, are the most common abnormal conditions observed. In the cord the vessels are occasionally found to have undergone changes identical in character with those already described as taking place in the arteries of the adult (p. 1092). The fœtus itself also shows evidence of disease in the great majority of cases in which it perishes before arriving at maturity, or is born dead at the full time. Mewis states that an examination of ninety-two syphilitic fœtuses showed the spleen to be diseased in seventy-two, the bones in sixty-four, the liver in fifty-six, the pancreas in fourteen, the supra-renal bodies in eleven, the lungs in three, and the skin in one only. In consequence of these diseases of the placenta and the fœtus, it often happens that early abortion or miscarriage takes place. Many consecutive miscarriages may take place in consequence of the parents being affected with constitutional syphilis. It is a common history in these cases that the period at which miscarriage takes place becomes later in each succeeding pregnancy, until at last, perhaps after a dead fœtus has been delivered at full term, a living child may be born bearing evidence of inherited syphilis. Such a history is very characteristic of syphilis, even if the parents have ceased to show any visible signs of the disease. When the parents are known to be syphilitic, if they be treated by a mercurial course, miscarriage can frequently be prevented, though the child may show some signs of the disease.

The offspring of syphilitic parents as a rule develop symptoms resembling in most points the acquired form of the disease. It is not impossible, however, that the taint may manifest itself by an impaired or depraved state of the constitution, and that syphilis may thus be a predisposing cause of scrofula or rickets. There is, however, no satisfactory evidence that this is the case.

The **Period at which the Symptoms manifest themselves** varies greatly. As a rule, a syphilitic child when born alive, though often small, badly developed, and cachectic in its appearance, shows no definite manifestations of the disease ; but in the course of a few weeks, usually from two to eight, the symptoms declare themselves. Diday and De Méric have collected a large number of cases, in most of which the signs of the disease developed in the fifth or sixth week. Many betrayed their disorder in the first month ; and in some few it was delayed until the child had attained the age of three months. The earlier the disease shows itself, the more fatal are its effects. Children who manifest no symptoms till they are two or three months old, usually recover their health in a short time.

The effects of inherited syphilis may also manifest themselves, even at the adult age. Hutchinson believes that this may take place without any signs of syphilis during infancy ; this view, however, is not entertained by Berkeley Hill, and most other writers on the disease. They assert that though they may have been slight, some symptoms have in every case been present during the early months of life. These cases are rare, and the following which fell under my own observation is a good instance. The patient was a young woman, aged seventeen, who was covered with marked syphilitic psoriasis, with which she had been affected for several years. The mother told me that, shortly after birth, evidences of infantile syphilis had appeared ; that these had yielded to treatment, but that, as the period of puberty approached, the psoriasis, which was truly of a syphilitic nature, had shown itself.

Symptoms.—The symptoms of inherited syphilis are sufficiently well marked in most cases, consisting principally of general constitutional disturbance, with affections of the skin, mucous membranes, bones, viscera, and eye, which more or less closely resemble the manifestations of acquired syphilis.

Constitutional Symptoms.—The first indication is often the atrophic and cachectic appearance of the child ; this not unfrequently shows itself at birth, without any more definite signs of the disease. Such children are often small, shrivelled, wan and wasted when born ; the face especially has an aged look, the features being pinched, the flesh soft and flabby, and the skin loose and wrinkled ; the complexion has a yellowish or earthy tinge, which has been compared to that of *café au lait*. These appearances are, however, by no means always present. Many syphilitic children are born apparently healthy and fat ; but they soon emaciate, when the cutaneous and other manifestations of the disease make their appearance a few weeks after birth. In slight cases, however, the child may remain fat and well-nourished, though anæmic, throughout the whole course of the symptoms.

Local Symptoms.—In the great majority of cases the most marked symptoms are due to the affections of the skin and mucous membranes. As in acquired syphilis the first appearance may be a roseolous eruption on the skin, but this is of short duration, and seldom clearly marked. The earliest marked feature

is usually the appearance of *mucous tubercles.* These form at the angles of the lips, in the cavity of the mouth, in the pharynx, in the nose, at the anus, in wherever the skin is moist, as in the folds of the groin, and between the scrotum and thigh. They are of the same nature and appearance as those met with in acquired syphilis.

The affection of the **nose** is amongst the most constant and characteristic features of the disease, and is usually the earliest local sign that declares itself. There is much congestive swelling of the mucous membrane, with a secretion of thick yellow offensive mucus, causing the child to make a peculiar snuffling noise in breathing, as if it had a chronic catarrh. This symptom is so constant that it has given rise to the popular name of "the snuffles" which is applied to congenital syphilis. The degree to which the nose is affected varies considerably. In the mildest cases the symptoms merely resemble those of a slight cold; in the most extreme forms the discharge dries into scabs at the nostrils, beneath which ulcers may form; mucous tubercles develop on the membrane, and ulceration may follow, leading to disease of the bones, with flattening of the bridge of the nose. In all cases free breathing through the nose is interfered with, sucking consequently becomes difficult, and the trouble in feeding the child is correspondingly increased.

The **mouth** is similarly affected, but usually in a less degree. Radiating fissures, sometimes extending somewhat deeply, are common on the lips, especially at the angles of the mouth. The mucous membrane of the cheeks and tongue is covered with mucous patches, and sometimes with superficial ulcers.

The mucous membrane of the **larynx** is congested and swollen in most cases, and sometimes actual mucous tubercles may be formed at the opening of the glottis. The laryngeal affection is the cause of the hoarse cry which usually forms a marked feature in the disease.

The **Eruptions on the Skin** are usually most abundant on the nates, scrotum, and the soles of the feet; hence, in examining a child, supposed to be syphilitic, these parts should always be looked at first. In moist situations the eruptions most frequently assume the form of smooth, flat mucous tubercles, varying in size from a pea to a threepenny-piece; they are slightly elevated, and covered with a slimy whitish secretion. Cracks or fissures are common at the anus as well as at the mouth. In the drier parts the eruption is often described as *squamous*, though it is not really scaly, but composed of smooth flat patches of a coppery red colour. These patches are often well-marked on the soles of the feet, and are followed by peeling of the cuticle.

Papular eruptions are not common. The vesicular, or bullous eruption, or *pemphigus*, is less common than those first mentioned, yet I have frequently seen it in syphilitic children. It appears in the form of vesicles which enlarge into bullа about the size of a split pea, with a dusky coppery areola; they dry into brown scales or scabs, and commonly occur simultaneously with mucous tubercles in other parts of the body. It is most frequently seen on the soles of the feet, and is not met with in children except in syphilis.

A pustular eruption or *Ecthyma* is also occasionally met with. The pustules dry early, leaving a black scab, beneath which ulceration may take place. It is met with only in very feeble children.

Subcutaneous gummata are met with occasionally in inherited syphilis, but seldom before the second year.

The *Hair* very commonly is thin, and is often lost from the posterior and lateral aspects of the head. The *Nails* are seldom affected, but may be brittle and grow irregularly.

When we consider the influence exercised by the syphilitic poison upon the skin and its appendages, the hair and nails, we should *à priori* have expected that the **teeth**, being developed from the same embryonic layer, would participate in the morbid processes induced by it in the allied structures. The fact of their doing so does not, however, appear to have attracted the notice of any observer, until J. Hutchinson directed the attention of the profession to this very interesting subject, and pointed out the destructive and special influence exercised upon the teeth by inherited syphilis. This injurious influence manifests itself both in the temporary and in the permanent teeth; but with its specific and peculiar characteristics only in the permanent set. It must not, however, be supposed that in all cases of infantile syphilis the teeth are affected; indeed, in many instances they are not, and it has been particularly pointed out by J. Hutchinson that it is only when there have been attacks of syphilitic stomatitis, that we are to expect to meet with these changes from their normal types in the teeth.

The *temporary teeth* of syphilitic infants are cut early, are of bad colour, and liable to a crumbling decay. The upper central incisors usually

Fig. 412.—Syphilitic Teeth from a boy aged 12 years.

Fig. 413.—Two Central Syphilitic Incisors Deeply Notched (Hutchinson

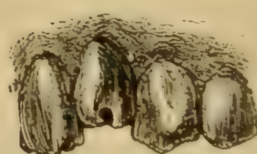


Fig. 414.—One Central Incisor Notched (Hutchinson).

suffer early, and always first; then the laterals become carious and drop out; and lastly, in some cases, though rarely, the canines wear away so as to present a tusk-like appearance. In consequence of the early decay of the incisors, children are often edentulous, so far as these teeth are concerned, from an early age, until the permanent ones are cut.

The *permanent teeth* present the more marked characteristics of an inherited syphilitic taint; and in these, as in the temporary, the disease declares itself chiefly in the incisors of the upper jaw, and first in the central ones. These will be observed to be usually of a bad colour, short, peggy, rounded at the angles, standing apart with interspaces or converging, and marked by a deep broad notch. They are soft and crumbling, are slender, and readily wear down (Figs. 412—414).

Besides the notching, the sides of the teeth are curved inwards towards one another, and thus the cutting edge becomes narrower than the crown. The teeth are also shorter than the others. The convergence of the sides causes the teeth to be somewhat separated, and to stand apart.

The **Bones** are very frequently affected in congenital syphilis, though until recently the changes that take place had been partly overlooked and partly confounded with rickets. The observations of Wegner, Parrot, Barlow, and others, have, however, clearly established the fact that the implication of the bones is second in frequency only to that of the skin.

Parrot states that the affections of the bones in hereditary syphilis assume two principal forms, one consisting in atrophy of the pre-existing structures, and the other in the development of new tissue. The Atrophic form he divides into two varieties. The first, to which he applies the term *Gelatiniform*, affects equally the cranium and the bones of the extremities. The bone is altered in colour, varying from a pale red or rose tint to different shades of yellow. The medulla becomes transparent, and is at last reduced to a network composed of vessels and delicate fibrillæ, the meshes of which are filled with a watery fluid. When the compact tissue is invaded it becomes rapidly decalcified ; the lamellæ seem to melt away, and large spaces appear between them, filled with a gelatinous substance like the altered medullary tissue. The second variety he terms *chondro-calcareous atrophy*. The most marked feature of this form is that the layer of calcified cartilage which naturally exists in the growing line between the shaft and the epiphysis assumes an abnormal thickness and loses all regularity in its outline. The calcified cartilage can be recognized by its density, brittleness, and chalky appearance. The formation of this brittle tissue renders the bone liable to fracture, and when the two forms of atrophy occur simultaneously this result is almost certain to take place. The fracture occurs always in close proximity to the epiphysis, and the accident is not unfrequently followed by suppuration, and from the close proximity to the joint suppurative arthritis may be set up. These fractures give rise to symptoms closely resembling paralysis of the affected limb, and Parrot has applied to the condition the name of *syphilitic pseudo-paralysis*. The limb hangs powerless, and, as a rule, there is singularly little pain, but the muscles respond readily to the Faradic current. The looseness of the epiphysis can sometimes be easily recognized, and some fine grating crepitus may be present.

The second form of disease of the bones in hereditary syphilis, to which Parrot applies the term *osteophytic*, is much more common. This also he divides into two varieties, according to the density of the new tissue. When this is hard and bony he terms it *osteoid ;* when soft, *fibro-spongioid* or *rachitic*. The osteoid form of growth may be met with at any period of childhood, and possibly may commence before birth ; the rachitic is never met with before the fifth or sixth month. The osteoid growth is composed of trabeculæ, arranged more or less perpendicularly to the surface of the bone, separated from each other by medullary tissue ; the new tissue contains large quantities of lime salts. It differs from normal bone in its brittleness and in its yellow or pink colour. In the rachitic form the new tissue is almost white, pearly, or yellowish in colour. It is fibroid in structure and very vascular. Various modifications between these two forms of tissue may be met with. Thus the osteoid tissue may be arranged in several layers, or spongy tissue may be found

covering the harder tissue. The periosteum covering the new growths is always distinctly thickened, and adheres firmly to it. There is almost always a distinct line of demarcation between the new tissue and the healthy bone beneath. The thickness of the growth varies from one-tenth to three-eighths of an inch on the long bones, but it may exceed this on those of the skull. In extreme cases almost the whole skeleton may be affected, but more commonly the diseased condition is met with in certain parts only. The most common situations are the lower end of the humerus, the tibia, the femur, and the ulna, where, unless the child be very fat, they can often be recognized during life. In the rachitic form the long bones may undergo modifications in form from bending or fracture, as in rickets.

The bones of the skull present changes of a very marked character. These most commonly consist of the formation of "bosses" of new bone, from the outer table only, around the anterior fontanelle and along the line of the sagittal and interfrontal sutures. Between these bosses the sutures may at first form distinct sulci, but later on they are often bridged over, and premature union may take place. If the child dies the bosses will be found to be composed of soft bone, very red in tint, sometimes even of a dark maroon colour. If macerated the new bone is porous and granular in structure, and is often deeply grooved by vascular channels. There is little if any thickening of the periosteum. The anterior part of the skull may reach a third of an inch or more in thickness. The effect of these growths is to give the forehead the rounded prominent form which was pointed out by Hutchinson many years ago as being often associated with other signs of congenital syphilis in later life. Barlow and Lees have pointed out that the condition known as *craniotabes* is also met with in syphilitic infants. In this the bones of the vault of the skull become extremely thin in circumscribed patches, so as to yield to gentle firm pressure, feeling like parchment beneath the finger. In some spots the bony material may entirely disappear, leaving only a thin membrane. These spots are most common in the occipital region, where the bone is exposed to direct pressure while the child is lying on its back, but they are also met with in the parietal bones. The bony growths are met with at any time during the first two years, but the irregularity they give rise to may be recognized at any age. Craniotabes occurs at an early period during the first year of life. Both conditions may occur in the same skull. In addition to the above diseases of the bones gummata are occasionally met with in the skull, and dactylitis, similar to that described as occurring in acquired syphilis, is not uncommon. Up to puberty chronic inflammation of various long bones, especially of the tibia, is occasionally met with in syphilitic subjects.

Under the name of **Chronic Interstitial Keratitis**, J. Hutchinson has described a disease which he believes to be uniformly due to hereditary syphilis. It occurs between the ages of 5 and 18, but may occur much earlier, even during the first year. It consists at first of a hazy condition of the cornea, giving it the appearance of ground glass, followed by vascularization, without any tendency to ulceration. The opacity commences in the centre, and both eyes are usually affected. The vascularity is not confined to the surface, but seems to pervade the whole thickness of the cornea. One eye is usually affected before the other. Under a carefully conducted course of mercurials and iodides, accompanied by tonics and good diet, the transparency of the cornea can usually be restored.

Chronic affections of the **Ear**, leading to deafness, are not uncommon in inherited syphilis. They occur sometimes in conjunction with interstitial keratitis in the eye. Their pathology is not yet certainly known.

The **lymphatic glands** show no special morbid conditions resulting from inherited syphilis.

Affections of the **Viscera** in congenital syphilis are by no means uncommon. They assume the same forms as in the adult, namely, general fibroid induration of the affected organ and the formation of gummata, the former condition being the more common. The spleen of syphilitic children is in most cases somewhat enlarged and hard. The liver is affected next in order of frequency. Syphilitic disease of the lung is met with only in children born dead, or dying soon after birth.

The *testicles* occasionally present a uniform, smooth, hard, painless enlargement, affecting the body of the gland, and corresponding in every respect to the same disease in the adult.

The *nervous system* is less commonly affected, but gummata are occasionally met with in the brain.

Evidence of Congenital Syphilis in later childhood or adult life.—The taint of congenital syphilis may manifest itself after the period of infancy by various chronic inflammations of bone, by diseases of the eye, and occasionally of the viscera ; and as these present, as a rule, no very definite signs of their origin, it is important to remember the points by which the nature of the case may be established. In the history we must inquire for miscarriages before the birth of the patient, for signs of syphilis in previous children born alive, and for symptoms of the disease in the parents, such as prolonged sore throat, eruptions on the skin, loss of hair, and pains in the bones. With regard to the patient, we must ask the period at which birth took place ; the appearance at birth, whether fat or thin ; the occurrence of snuffles and sores on the bottom. In examining the patient, we must look for stunted growth ; a flat or ill-developed bridge to the nose ; radiating scars at the angles of the mouth. The forehead must be examined for bosses in the region of the anterior fontanelle, and the humerus, femur, and tibia should be searched for thickenings or want of symmetry in the two sides. The eye also should be examined for interstitial keratitis, and the teeth for the signs already described. All these signs are seldom present together, but enough to enable the Surgeon to come to a correct conclusion will always be found in any case in which the disease has been sufficiently severe to affect the patient after early childhood.

Prognosis.—If the child is born with signs of syphilis, it usually dies. Emaciation increases, and death takes place either directly from the disease or in consequence of some complication, as diarrhœa, bronchitis, or pneumonia. If the child is born apparently fat and well, the prognosis depends much on the period at which the symptoms appear ; the later the appearance, the better the prognosis. Most cases recover in which the symptoms do not manifest themselves till after the end of the first month.

TREATMENT.—The occurrence of syphilis in the infant may be *prevented* by putting the infected mother on a mercurial course so soon as her pregnancy is ascertained ; this indeed may be necessary in order to prevent miscarriage, but should be done cautiously, and by inunction rather than by mercury administered by the mouth. Should repeated miscarriages have occurred, as

the consequence of constitutional syphilis, one or other, or both of the parents, if both are at fault, should be put upon a mercurial course; and thus the recurrence of this accident may be prevented.

The **Curative Treatment** as regards the child is extremely simple. It should be nursed by its mother, if she have sufficient milk and is in good health. If this is impossible, it should be brought up by hand, and must not be given to a wet-nurse, lest it infect her. (See p. 1082.) The child must then be put under the influence of mercury, which in these cases produces the most unmistakeable effects; indeed, the ready manner in which all disease may be eradicated from the system of a syphilitic child by this mineral, is perhaps one of the strongest proofs that can be adduced of the specific character of its action on the venereal poison. The mercury may be given by the mouth in the form of small doses of grey powder; but, as it often purges the child when administered in this way, Sir Benjamin Brodie has recommended its introduction into the system by inunction, which process I invariably employ, and have found it a most successful mode of treating the disease. The most convenient plan is, as recommended by Brodie, to spread a drachm of mercurial ointment on the under part of a flannel roller stitched round the thigh just above the knee, and to renew this every day. The treatment should be continued until all rash and snuffling have disappeared, when, the mercury having been discontinued, the cure may be perfected by the administration of small doses of iodide of potassium in milk or cod-liver oil. The skin must be kept in a healthy state by a hot-bath every day. Occasionally the cutaneous manifestations of infantile syphilis are complicated with, and obscured by, some of the common diseases of the skin incident to early childhood; more particularly with eczema impetiginodes of the head, face, and body. In these circumstances, the diagnosis may not be easy, though the history of the case, the concomitant appearance of two forms of the disease, and the existence of snuffling and cachexy, tend to establish it. The eczema also, in these circumstances, is browner and more squamous than usual. In cases such as these, the best plan is to treat the syphilitic affection first with the mercurial inunction, and then to put the child under a mild course of the liquor hydrargyri et arsenici iodidi, one to two minims for a dose, keeping it at the same time on a good nourishing diet.

INDEX TO VOLUME I.

END OF VOLUME I.

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